

```

disp('Program Plasma6.m');
%; plasma6.m - program to compute current required for fusion in bottle
%;
%; compute the ring equation
; - int(dB) = int(i ds x r / r^2)
;
%; - Therefore
%;
%; - int(dBx) = int(dsy*rz - ry*dsz/ r^2)
%; - int(dBy) = int(dsx*rz - rx*dsz/ r^2)
%; - int(dBz) = int(dsx*ry - rx*dsy/ r^2)
%; - convert each of these into an f(x,y,z,r1,px1,pyl,pz1,th1,th2)
%; - polynomial matrix: each term ^4 ^3 ^2 ^1 - 0.5 7.0 35.0 150.0
%; - B vector: i ds x r/ r^2 for 64 different points for each 3 var.
%; - int(dBx,dBy,dBz) = (expressed in terms of vectors)
fid = fopen('g:/draw1/plasma6.txt','w');
fprintf(fid,'\nPlasma6.m - Output\n');
syms x1 y1 z1 x0 y0 z0 th1 r1 atmp;
syms dBx dBy dBz Bx By Bz B u0;
u0 = 1/(10^7);
x1 = r1*cos(th1) + x0;
y1 = r1*sin(th1) + y0;
z1 = z0;
syms x2 y2 z2 r01 th2 the1;
r01 = sqrt((x1 - x0)^2 + (y1 - y0)^2 + (z1 - z0)^2);
th2 = atan((y1 - y0)/(x1 - x0));
the1 = acos((z1 - z0)/(th2));
x2 = r01*cos(th2)*sin(the1);
y2 = r01*sin(th2)*sin(the1);
z2 = r01*cos(the1);
syms r11 r1x r1y r1z;
syms px1 pyl pz1;
1x = (px1 - x2);
1y = (pyl - y2);
r1z = (pz1 - z2);
r11 = sqrt(r1x^2 + r1y^2 + r1z^2);
syms coefr1 coefr2 coefr3 coefr4 coefr5 ar1 br1 r1lap;
r1 = 1.0;
th1 = 0.0;
px1 = 2.0;
pyl = 0.0;
pz1 = 0.0;
ar1 = [r1x^4 r1x^3 r1x^2 r1x^1;];
br1 = [eval(r11);];
px1 = 8;
ar1 = [ar1; r1x^4 r1x^3 r1x^2 r1x^1;];
br1 = [br1; eval(r11);];
px1 = 16;
ar1 = [ar1; r1x^4 r1x^3 r1x^2 r1x^1;];
br1 = [br1; eval(r11);];
px1 = 48;
ar1 = [ar1; r1x^4 r1x^3 r1x^2 r1x^1;];
br1 = [br1; eval(r11);];
coefr1 = pinv(eval(ar1))*br1;
disp('coefr1...');
px1 = 2.0;
pyl = 0.0;
pz1 = 0.0;
r1 = 1.0;
th1 = 3.14159/2;
ar1 = [th1^4 th1^3 th1^2 th1^1;];
r1 = [eval(r11) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;];
th1 = 3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; eval(r11) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;];
1;];

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th1 = 3*3.14159/2;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; eval(r11) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;];
th1 = 2*3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; eval(r11) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;];
coefr2 = pinv(ar1)*real(br1);
disp('coefr2...');
r1 = 1.0;
py1 = 0.0;
pz1 = 0.0;
th1 = 0.0;
px1 = 2;
ar1 = [px1^4 px1^3 px1^2 px1^1;];
atmp = eval(r11) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;];
px1 = 8;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = eval(r11) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;];
px1 = 18;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = eval(r11) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;];
px1 = 48;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = eval(r11) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;];
coefr3 = pinv(ar1)*real(br1);
disp('coefr3...');
r1 = 1.0;
px1 = 0.0;
pz1 = 0.0;
th1 = 0.0;
py1 = 2;
ar1 = [py1^4 py1^3 py1^2 py1^1;];
atmp = eval(r11) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;];
py1 = 8;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = eval(r11) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;];
py1 = 18;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = eval(r11) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;];
py1 = 48;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = eval(r11) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;];
coefr4 = pinv(ar1)*real(br1);
disp('coefr4...');
px1 = 0.0;
py1 = 0.0;

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th1 = 0.0;
r1 = 1.0;
pz1 = 2;
ar1 = [pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = eval(r11) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^1;];
pz1 = 8;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = eval(r11) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^1;];
pz1 = 32;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = eval(r11) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^1;];
pz1 = 48;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = eval(r11) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^1;];
coefr5 = pinv(ar1)*real(br1);
disp('coefr5...');
syms r1 th1 px1 py1 pz1;
r1lap = coefr1(1)*r1^4 + coefr1(2)*r1^3 + coefr1(3)*r1^2 + coefr1(4)*r1^1;
r1lap = r1lap + coefr2(1)*th1^4 + coefr2(2)*th1^3 + coefr2(3)*th1^2 + coefr2(4)*th1^1;
r1lap = r1lap + coefr3(1)*px1^4 + coefr3(2)*px1^3 + coefr3(3)*px1^2 + coefr3(4)*px1^1;
r1lap = r1lap + coefr4(1)*py1^4 + coefr4(2)*py1^3 + coefr4(3)*py1^2 + coefr4(4)*py1^1;
r1lap = r1lap + coefr5(1)*pz1^4 + coefr5(2)*pz1^3 + coefr5(3)*pz1^2 + coefr5(4)*pz1^1;
disp('r1lap...');

syms dBxn dByn dBzn dBxnap dBynap dBznep;
syms diffy2 diffx2 diffz2 diffy2ap diffxap diffz2ap;
diffy2 = eval(diff(y2));
diffx2 = diff(x2);
diffz2 = eval(diff(z2));

x0 = 0;
y0 = 0;
z0 = 0;
r1 = 1;
px1 = 2.0;
py1 = 0.0;
pz1 = 0.0;
th1 = 3.14159/2;
ar1 = [th1^4 th1^3 th1^2 th1^1;];
br1 = [eval(diffy2);];
th1 = 3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; eval(diffy2);];
th1 = 3*3.14159/2;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; eval(diffy2);];
th1 = 2*3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; eval(diffy2);];
coefr1 = pinv(ar1)*br1;
r1 = 1;

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px1 = 0.0;
pz1 = 0.0;
pz1 = 0.0;
th1 = 0.0;
r1 = [r1^4 r1^3 r1^2 r1^1;];
br1 = [eval(diffy2) - coefr1(1)*th1^4 - coefr1(2)*th1^3 - coefr1(3)*th1^2 - coefr1(4)*th1^1;];
r1 = 2;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; eval(diffy2) - coefr1(1)*th1^4 - coefr1(2)*th1^3 - coefr1(3)*th1^2 - coefr1(4)*th1^1;];
r1 = 8;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; eval(diffy2) - coefr1(1)*th1^4 - coefr1(2)*th1^3 - coefr1(3)*th1^2 - coefr1(4)*th1^1;];
r1 = 32;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; eval(diffy2) - coefr1(1)*th1^4 - coefr1(2)*th1^3 - coefr1(3)*th1^2 - coefr1(4)*th1^1;];
coefr2 = pinv(ar1)*br1;
diffy2ap = coefr1(1)*th1^4 + coefr1(2)*th1^3 + coefr1(3)*th1^2 + coefr1(4)*th1^1;
diffy2ap = diffy2ap + coefr2(1)*r1^4 + coefr2(2)*r1^3 + coefr2(3)*r1^2 + coefr2(4)*r1^1;

x0 = 0;
y0 = 0;
z0 = 0;
r1 = 1;
th1 = 3.14159/2;
ar1 = [th1^4 th1^3 th1^2 th1^1;];
br1 = [eval(diffx2);];
th1 = 3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; eval(diffx2);];
th1 = 3*3.14159/2;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; eval(diffx2);];
th1 = 2*3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; eval(diffx2);];
coefr1 = pinv(ar1)*br1;
r1 = 1;
ar1 = [r1^4 r1^3 r1^2 r1^1;];
br1 = [eval(diffx2) - coefr1(1)*th1^4 - coefr1(2)*th1^3 - coefr1(3)*th1^2 - coefr1(4)*th1^1;];
r1 = 2;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; eval(diffx2) - coefr1(1)*th1^4 - coefr1(2)*th1^3 - coefr1(3)*th1^2 - coefr1(4)*th1^1;];
r1 = 8;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; eval(diffx2) - coefr1(1)*th1^4 - coefr1(2)*th1^3 - coefr1(3)*th1^2 - coefr1(4)*th1^1;];
r1 = 32;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; eval(diffx2) - coefr1(1)*th1^4 - coefr1(2)*th1^3 - coefr1(3)*th1^2 - coefr1(4)*th1^1;];
coefr2 = pinv(ar1)*br1;
diffx2ap = coefr1(1)*th1^4 + coefr1(2)*th1^3 + coefr1(3)*th1^2 + coefr1(4)*th1^1;
diffx2ap = diffx2ap + coefr2(1)*r1^4 + coefr2(2)*r1^3 + coefr2(3)*r1^2 + coefr2(4)*r1^1;
x0 = 0;
y0 = 0;
z0 = 0;
r1 = 1;
th1 = 3.14159/2;
ar1 = [th1^4 th1^3 th1^2 th1^1;];
br1 = [diffz2;];

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th1 = 3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; diffz2;];
th1 = 3*3.14159/2;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; diffz2;];
th1 = 2*3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; diffz2;];
coefr1 = pinv(ar1)*br1;
r1 = 1;
ar1 = [r1^4 r1^3 r1^2 r1^1;];
br1 = [diffz2 - coefr1(1)*th1^4 - coefr1(2)*th1^3 - coefr1(3)*th1^2 - coefr1(4)*th1^1;];
r1 = 2;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; diffz2 - coefr1(1)*th1^4 - coefr1(2)*th1^3 - coefr1(3)*th1^2 - coefr1(4)*th1^1;];
r1 = 8;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; diffz2 - coefr1(1)*th1^4 - coefr1(2)*th1^3 - coefr1(3)*th1^2 - coefr1(4)*th1^1;];
r1 = 32;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; diffz2 - coefr1(1)*th1^4 - coefr1(2)*th1^3 - coefr1(3)*th1^2 - coefr1(4)*th1^1;];
coefr2 = pinv(ar1)*br1;
diffz2ap = coefr1(1)*th1^4 + coefr1(2)*th1^3 + coefr1(3)*th1^2 + coefr1(4)*th1^1;
diffz2ap = diffz2ap + coefr2(1)*r1^4 + coefr2(2)*r1^3 + coefr2(3)*r1^2 + coefr2(4)*r1^1;

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syms r1 th1 px1 py1 pz1;
dBxn = eval(diffy2ap*r1z - rly*diffz2ap);
dByn = eval(diffx2ap*r1z - rlx*diffz2ap);
dBzn = eval(diffx2ap*r1y - rly*diffy2ap);
%;ar1 = [r1 px1 py1 pz1]

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th1 = 0.0;
px1 = 2.0;
py1 = 0.0;
pz1 = 0.0;
r1 = 2;
ar1 = [r1^4 r1^3 r1^2 r1^1;];
br1 = [eval(dBxn);];
r1 = 8;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; eval(dBxn);];
r1 = 16;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; eval(dBxn);];
r1 = 48;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; eval(dBxn);];
coefr1 = pinv(ar1)*real(br1);
disp('coefr1...');
px1 = 0.0;
py1 = 0.0;
pz1 = 0.0;
r1 = 1.0;
th1 = 3.14159/2;
ar1 = [th1^4 th1^3 th1^2 th1^1;];
br1 = [eval(dBxn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;];
th1 = 3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; eval(dBxn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;];
th1 = 3*3.14159/2;

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ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; eval(dBxn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;];
th1 = 2*3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; eval(dBxn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;];
coefr2 = pinv(ar1)*real(br1);
disp('coefr2...');
py1 = 0.0;
pz1 = 0.0;
r1 = 1.0;
th1 = 0.0;
px1 = 2;
ar1 = [px1^4 px1^3 px1^2 px1^1;];
atmp = eval(dBxn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;];
px1 = 8;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = eval(dBxn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;];
px1 = 18;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = eval(dBxn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;];
px1 = 48;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = eval(dBxn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;];
coefr3 = pinv(ar1)*real(br1);
disp('coefr3...');
px1 = 0.0;
pz1 = 0.0;
th1 = 0.0;
r1 = 0.0;
py1 = 2;
ar1 = [py1^4 py1^3 py1^2 py1^1;];
atmp = eval(dBxn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;];
py1 = 8;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = eval(dBxn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;];
py1 = 18;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = eval(dBxn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;];
py1 = 48;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = eval(dBxn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;];
coefr4 = pinv(ar1)*real(br1);
disp('coefr4...');
px1 = 0.0;
py1 = 0.0;
th1 = 0.0;

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r1 = 0.0;
pz1 = 2;
ar1 = [pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = eval(dBxn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^1;];
pz1 = 8;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = eval(dBxn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^1;];
pz1 = 32;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = eval(dBxn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^1;];
pz1 = 48;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = eval(dBxn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^1;];
coefr5 = pinv(ar1)*real(br1);
disp('coefr5...');
syms r1 th1 px1 py1 pz1;
dBxnap = coefr1(1)*r1^4 + coefr1(2)*r1^3 + coefr1(3)*r1^2 + coefr1(4)*r1^1;
dBxnap = dBxnap + coefr2(1)*th1^4 + coefr2(2)*th1^3 + coefr2(3)*th1^2 + coefr2(4)*th1^1;
dBxnap = dBxnap + coefr3(1)*px1^4 + coefr3(2)*px1^3 + coefr3(3)*px1^2 + coefr3(4)*px1^1;
dBxnap = dBxnap + coefr4(1)*py1^4 + coefr4(2)*py1^3 + coefr4(3)*py1^2 + coefr4(4)*py1^1;
dBxnap = dBxnap + coefr5(1)*pz1^4 + coefr5(2)*pz1^3 + coefr5(3)*pz1^2 + coefr5(4)*pz1^1;
disp('dBxnap...');

syms r1 th1 px1 py1 pz1;

r1 = 1.0;
px1 = 2.0;
py1 = 0.0;
pz1 = 0.0;
ar1 = [r1^4 r1^3 r1^2 r1^1;];
br1 = [eval(dByn);];
r1 = 8;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; eval(dByn);];
r1 = 16;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; eval(dByn);];
r1 = 48;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; eval(dByn);];
coefr1 = pinv(ar1)*real(br1);
disp('coefr1...');
th1 = 3.14159/2;
ar1 = [th1^4 th1^3 th1^2 th1^1;];
br1 = [eval(dByn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;];
th1 = 3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; eval(dByn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;];
th1 = 3*3.14159/2;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];

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br1 = [br1; eval(dByn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;];
th1 = 2*3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; eval(dByn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;];
coefr2 = pinv(ar1)*real(br1);
disp('coefr2...');
py1 = 0.0;
pz1 = 0.0;
th1 = 0.0;
r1 = 1.0;
px1 = 2;
ar1 = [px1^4 px1^3 px1^2 px1^1;];
atmp = eval(dByn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;];
px1 = 8;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = eval(dByn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;];
px1 = 18;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = eval(dByn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;];
px1 = 48;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = eval(dByn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;];
coefr3 = pinv(ar1)*real(br1);
disp('coefr3...');
px1 = 0.0;
pz1 = 0.0;
th1 = 0.0;
r1 = 1.0;
py1 = 2;
ar1 = [py1^4 py1^3 py1^2 py1^1;];
atmp = eval(dByn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;];
py1 = 8;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = eval(dByn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;];
py1 = 18;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = eval(dByn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;];
py1 = 48;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = eval(dByn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;];
coefr4 = pinv(ar1)*real(br1);
disp('coefr4...');
px1 = 0.0;
py1 = 0.0;
th1 = 0.0;
r1 = 1.0;

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pz1 = 2;
ar1 = [pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = eval(dByn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^1;];
pz1 = 8;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = eval(dByn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^1;];
pz1 = 32;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = eval(dByn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^1;];
pz1 = 48;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = eval(dByn) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^1;];
coefr5 = pinv(ar1)*real(br1)';
disp('coefr5...');
syms r1 th1 px1 py1 pz1;
dBynap = coefr1(1)*r1^4 + coefr1(2)*r1^3 + coefr1(3)*r1^2 + coefr1(4)*r1^1;
dBynap = dBynap + coefr2(1)*th1^4 + coefr2(2)*th1^3 + coefr2(3)*th1^2 + coefr2(4)*th1^1;
dBynap = dBynap + coefr3(1)*px1^4 + coefr3(2)*px1^3 + coefr3(3)*px1^2 + coefr3(4)*px1^1;
dBynap = dBynap + coefr4(1)*py1^4 + coefr4(2)*py1^3 + coefr4(3)*py1^2 + coefr4(4)*py1^1;
dBynap = dBynap + coefr5(1)*pz1^4 + coefr5(2)*pz1^3 + coefr5(3)*pz1^2 + coefr5(4)*pz1^1;
disp('dBynap...');

syms r1 th1 px1 py1 pz1;

px1 = 2.0;
py1 = 0.0;
pz1 = 0.0;
th1 = 0.0;
r1 = 1.0;
ar1 = [r1^4 r1^3 r1^2 r1^1;];
br1 = [dBzn;];
r1 = 8;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; dBzn;];
r1 = 16;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; dBzn;];
r1 = 48;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; dBzn;];
coefr1 = pinv(ar1)*real(br1);
disp('coefr1...');
px1 = 0.0;
py1 = 0.0;
pz1 = 0.0;
r1 = 1.0;
th1 = 3.14159/2;
ar1 = [th1^4 th1^3 th1^2 th1^1;];
br1 = [dBzn - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;];
th1 = 3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];

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br1 = [br1; dBzn - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;];
th1 = 3*3.14159/2;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; dBzn - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;];
th1 = 2*3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; dBzn - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;];
coefr2 = pinv(ar1)*real(br1);
disp('coefr2...');
py1 = 0.0;
pz1 = 0.0;
th1 = 0.0;
r1 = 1.0;
px1 = 2;
ar1 = [px1^4 px1^3 px1^2 px1^1;];
atmp = dBzn - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;];
px1 = 8;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = dBzn - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;];
px1 = 18;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = dBzn - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;];
px1 = 48;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = dBzn - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;];
coefr3 = pinv(ar1)*real(br1);
disp('coefr3...');
px1 = 0.0;
pz1 = 0.0;
th1 = 0.0;
r1 = 1.0;
py1 = 2;
ar1 = [py1^4 py1^3 py1^2 py1^1;];
atmp = dBzn - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;];
py1 = 8;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = dBzn - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;];
py1 = 18;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = dBzn - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;];
py1 = 48;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = dBzn - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;];
coefr4 = pinv(ar1)*real(br1);
disp('coefr4...');
px1 = 0.0;
py1 = 0.0;
r1 = 1.0;

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```

th1 = 0.0;
pz1 = 2;
ar1 = [pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = dBzn - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^1;];
pz1 = 8;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = dBzn - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^1;];
pz1 = 32;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = dBzn - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^1;];
pz1 = 48;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = dBzn - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^1;];
coefr5 = pinv(ar1)*real(br1);
disp('coefr5...');
syms r1 th1 px1 py1 pz1;
dBzn = coefr1(1)*r1^4 + coefr1(2)*r1^3 + coefr1(3)*r1^2 + coefr1(4)*r1^1;
dBzn = dBzn + coefr2(1)*th1^4 + coefr2(2)*th1^3 + coefr2(3)*th1^2 + coefr2(4)*th1^1;
dBzn = dBzn + coefr3(1)*px1^4 + coefr3(2)*px1^3 + coefr3(3)*px1^2 + coefr3(4)*px1^1;
dBzn = dBzn + coefr4(1)*py1^4 + coefr4(2)*py1^3 + coefr4(3)*py1^2 + coefr4(4)*py1^1;
dBzn = dBzn + coefr5(1)*pz1^4 + coefr5(2)*pz1^3 + coefr5(3)*pz1^2 + coefr5(4)*pz1^1;
disp('dBzn...');

syms r1 th1 px1 py1 pz1;

r1 = 1.0;
th1 = 0.0;
px1 = 2.0;
py1 = 0.0;
pz1 = 0.0;
ar1 = [r1^4 r1^3 r1^2 r1^1;];
br1 = [real(eval(dBzn)/eval(r1lap));];
px1 = 8;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; real(eval(dBzn)/eval(r1lap));];
px1 = 16;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; real(eval(dBzn)/eval(r1lap));];
px1 = 48;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1;];
br1 = [br1; real(eval(dBzn)/eval(r1lap));];
coefr1 = pinv(ar1)*real(br1);
disp('coefr1...');
px1 = 0.0;
py1 = 0.0;
pz1 = 0.0;
r1 = 1.0;
th1 = 3.14159/2;
ar1 = [th1^4 th1^3 th1^2 th1^1;];
br1 = [real(eval(dBzn)/eval(r1lap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;];

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th1 = 3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; real(eval(dBxnap)/eval(rllap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;];
h1 = 3*3.14159/2;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; real(eval(dBxnap)/eval(rllap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;];
th1 = 2*3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; real(eval(dBxnap)/eval(rllap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;];
coefr2 = pinv(ar1)*real(br1);
disp('coefr2...');
px1 = 2.0;
py1 = 0.0;
th1 = 0.0;
r1 = 1.0;
ar1 = [px1^4 px1^3 px1^2 px1^1;];
atmp = real(eval(dBxnap)/eval(rllap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;];
px1 = 8;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = real(eval(dBxnap)/eval(rllap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;];
px1 = 18;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = real(eval(dBxnap)/eval(rllap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;];
px1 = 48;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = real(eval(dBxnap)/eval(rllap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;];
coefr3 = pinv(ar1)*real(br1);
disp('coefr3...');
px1 = 0.0;
pz1 = 0.0;
th1 = 0.0;
r1 = 1.0;
py1 = 2;
ar1 = [py1^4 py1^3 py1^2 py1^1;];
atmp = real(eval(dBxnap)/eval(rllap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;];
py1 = 8;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = real(eval(dBxnap)/eval(rllap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;];
py1 = 18;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = real(eval(dBxnap)/eval(rllap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 - coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;];

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py1 = 48;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = real(eval(dBxnap)/eval(r1lap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^
1;];
coefr4 = pinv(ar1)*real(br1);
disp('coefr4...');
px1 = 0.0;
py1 = 0.0;
th1 = 0.0;
r1 = 1.0;
pz1 = 2;
ar1 = [pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = real(eval(dBxnap)/eval(r1lap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^1;];
pz1 = 8;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = real(eval(dBxnap)/eval(r1lap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^
1;];
pz1 = 32;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = real(eval(dBxnap)/eval(r1lap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^
1;];
pz1 = 48;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = real(eval(dBxnap)/eval(r1lap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^
1;];
coefr5 = pinv(ar1)*real(br1);
disp('coefr5...');
syms r1 th1 px1 py1 pz1;
dBx = coefr1(1)*r1^4 + coefr1(2)*r1^3 + coefr1(3)*r1^2 + coefr1(4)*r1^1;
dBx = dBx + coefr2(1)*th1^4 + coefr2(2)*th1^3 + coefr2(3)*th1^2 + coefr2(4)*th1^1;
dBx = dBx + coefr3(1)*px1^4 + coefr3(2)*px1^3 + coefr3(3)*px1^2 + coefr3(4)*px1^1;
dBx = dBx + coefr4(1)*py1^4 + coefr4(2)*py1^3 + coefr4(3)*py1^2 + coefr4(4)*py1^1;
dBx = dBx + coefr5(1)*pz1^4 + coefr5(2)*pz1^3 + coefr5(3)*pz1^2 + coefr5(4)*pz1^1;
disp('dBx...');

r1 = 1.0;

circle1x = u0*int(dBx,th1,0,2*3.14159);
disp('finished circle1x...');

fprintf(fid,'\n\nCircle1x = Sum of: \n');
for il = 1:4
    fprintf(fid,'%20.12f',coefr1(il));
    fprintf(fid,' px1^%li',il);
    fprintf(fid,'\n');
end

```

```

for i1 = 1:4
    fprintf(fid,'%20.12f',coefr2(i1));
    fprintf(fid,' py1^%li',i1);
    fprintf(fid,'\n');
end
for i1 = 1:4
    fprintf(fid,'%20.12f',coefr3(i1));
    fprintf(fid,' pz1^%li',i1);
    fprintf(fid,'\n');
end
for i1 = 1:4
    fprintf(fid,'%20.12f',coefr4(i1));
    fprintf(fid,' th1^%li',i1);
    fprintf(fid,'\n');
end
for i1 = 1:4
    fprintf(fid,'%20.12f',coefr5(i1));
    fprintf(fid,' th2^%li',i1);
    fprintf(fid,'\n');
end
syms tcirclelx tcirclely tcirclelz test1 test2 test3 test4 test5;
tcirclelx = coefr1(1)*test1^4 + coefr1(2)*test1^3 + coefr1(3)*test1^2 + coefr1(4)*test1^1;
tcirclelx = tcirclelx + coefr2(1)*test2^4 + coefr2(2)*test2^3 + coefr2(3)*test2^2 + coefr2(4)*test2^1;
tcirclelx = tcirclelx + coefr3(1)*test3^4 + coefr3(2)*test3^3 + coefr3(3)*test3^2 + coefr3(4)*test3^1;
tcirclelx = tcirclelx + coefr4(1)*test4^4 + coefr4(2)*test4^3 + coefr4(3)*test4^2 + coefr4(4)*test4^1;
tcirclelx = tcirclelx + coefr5(1)*test5^4 + coefr5(2)*test5^3 + coefr5(3)*test5^2 + coefr5(4)*test5^1;
test1 = 2*r1;
test2 = 0.0;
test3 = 0.0;
test4 = 0.0;
test5 = 0.0;
fprintf(fid,'\n\nTest of circlelx:');
fprintf(fid,'\npx1 = %20.12f',test1);
fprintf(fid,'\npy1 = %20.12f',test2);
fprintf(fid,'\npz1 = %20.12f',test3);
fprintf(fid,'\nth1 = %20.12f',test4);
fprintf(fid,'\nth2 = %20.12f',test5);
fprintf(fid,'\ncirclelx = %20.12f',eval(tcirclelx));
fprintf(fid,'\n');

```

```

syms r1 th1 px1 py1 pz1;

```

```

r1 = 1.0;
th1 = 0.0;
px1 = 0.0;
py1 = 0.0;
pz1 = 0.0;
ar1 = [r1^4 r1^3 r1^2 r1^1];
br1 = [real(eval(dBynap)/eval(r1lap))];
r1 = 8;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1];
br1 = [br1; real(eval(dBynap)/eval(r1lap))];
r1 = 16;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1];
br1 = [br1; real(eval(dBynap)/eval(r1lap))];
r1 = 48;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1];
br1 = [br1; real(eval(dBynap)/eval(r1lap))];
coefr1 = pinv(ar1)*real(br1);
disp('coefr1...');
px1 = 0.0;

```

```

py1 = 0.0;
th1 = 0.0;
r1 = 1.0;
th1 = 20;
ar1 = [th1^4 th1^3 th1^2 th1^1;];
br1 = [real(eval(dBynap)/eval(r1lap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;];
th1 = 80;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; real(eval(dBynap)/eval(r1lap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*
r1^2 - coefr1(4)*r1^1;];
th1 = 320;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; real(eval(dBynap)/eval(r1lap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*
r1^2 - coefr1(4)*r1^1;];
th1 = 720;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1;];
br1 = [br1; real(eval(dBynap)/eval(r1lap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*
r1^2 - coefr1(4)*r1^1;];
coefr2 = pinv(ar1)*real(br1);
disp('coefr2...');
py1 = 0.0;
px1 = 0.0;
r1 = 1.0;
th1 = 0.0;
pz1 = 2;
ar1 = [px1^4 px1^3 px1^2 px1^1;];
atmp = real(eval(dBynap)/eval(r1lap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
br1 = [atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;];
pz1 = 8;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = real(eval(dBynap)/eval(r1lap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^
1;];
pz1 = 18;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = real(eval(dBynap)/eval(r1lap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^
1;];
pz1 = 48;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1;];
atmp = real(eval(dBynap)/eval(r1lap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^
1;];
coefr3 = pinv(ar1)*real(br1);
disp('coefr3...');
px1 = 0.0;
pz1 = 0.0;
r1 = 1.0;
th1 = 0.0;
py1 = 2;
ar1 = [py1^4 py1^3 py1^2 py1^1;];
atmp = real(eval(dBynap)/eval(r1lap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;];
py1 = 8;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = real(eval(dBynap)/eval(r1lap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^

```

```

1];
py1 = 18;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = real(eval(dBynap)/eval(rllap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^
1];
py1 = 48;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = real(eval(dBynap)/eval(rllap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^
1];
coefr4 = pinv(ar1)*real(br1);
disp('coefr4...');
px1 = 0.0;
py1 = 0.0;
r1 = 1.0;
th1 = 0.0;
pz1 = 2;
ar1 = [pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = real(eval(dBynap)/eval(rllap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^1;];
pz1 = 8;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = real(eval(dBynap)/eval(rllap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^
1];
pz1 = 32;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = real(eval(dBynap)/eval(rllap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^
1];
pz1 = 48;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = real(eval(dBynap)/eval(rllap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^
1];
coefr5 = pinv(ar1)*real(br1);
disp('coefr5...');
syms r1 th1 px1 py1 pz1;
dBy = coefr1(1)*r1^4 + coefr1(2)*r1^3 + coefr1(3)*r1^2 + coefr1(4)*r1^1;
dBy = dBy + coefr2(1)*th1^4 + coefr2(2)*th1^3 + coefr2(3)*th1^2 + coefr2(4)*th1^1;
dBy = dBy + coefr3(1)*px1^4 + coefr3(2)*px1^3 + coefr3(3)*px1^2 + coefr3(4)*px1^1;
dBy = dBy + coefr4(1)*py1^4 + coefr4(2)*py1^3 + coefr4(3)*py1^2 + coefr4(4)*py1^1;
dBy = dBy + coefr5(1)*pz1^4 + coefr5(2)*pz1^3 + coefr5(3)*pz1^2 + coefr5(4)*pz1^1;
disp('dBy...');
r1 = 1.0;

circlely = u0*int(dBy,th1,0,2*3.14159);
disp('finished circlely...');

```



```

fprintf(fid,'\n\nCirclely = Sum of: \n');
for il = 1:4
    fprintf(fid,'%20.12f',coefr1(il));
    fprintf(fid,' px1^%li',il);
    fprintf(fid,'\n');
end
for il = 1:4
    fprintf(fid,'%20.12f',coefr2(il));
    fprintf(fid,' pyl^%li',il);
    fprintf(fid,'\n');
end
for il = 1:4
    fprintf(fid,'%20.12f',coefr3(il));
    fprintf(fid,' pz1^%li',il);
    fprintf(fid,'\n');
end
for il = 1:4
    fprintf(fid,'%20.12f',coefr4(il));
    fprintf(fid,' th1^%li',il);
    fprintf(fid,'\n');
end
for il = 1:4
    fprintf(fid,'%20.12f',coefr5(il));
    fprintf(fid,' th2^%li',il);
    fprintf(fid,'\n');
end
syms test1 test2 test3 test4 test5;
tcirclely = coefr1(1)*test1^4 + coefr1(2)*test1^3 + coefr1(3)*test1^2 + coefr1(4)*test1^1;
tcirclely = tcirclely + coefr2(1)*test2^4 + coefr2(2)*test2^3 + coefr2(3)*test2^2 + coefr2
(4)*test2^1;
tcirclely = tcirclely + coefr3(1)*test3^4 + coefr3(2)*test3^3 + coefr3(3)*test3^2 + coefr3
(4)*test3^1;
tcirclely = tcirclely + coefr4(1)*test4^4 + coefr4(2)*test4^3 + coefr4(3)*test4^2 + coefr4
(4)*test4^1;
tcirclely = tcirclely + coefr5(1)*test5^4 + coefr5(2)*test5^3 + coefr5(3)*test5^2 + coefr5
(4)*test5^1;
test1 = 2*r1;
test2 = 0.0;
test3 = 0.0;
test4 = 0.0;
test5 = 0.0;
fprintf(fid,'\n\nTest of circlely:');
fprintf(fid,'\npx1 = %20.12f',test1);
fprintf(fid,'\npy1 = %20.12f',test2);
fprintf(fid,'\npz1 = %20.12f',test3);
fprintf(fid,'\nth1 = %20.12f',test4);
fprintf(fid,'\nth2 = %20.12f',test5);
fprintf(fid,'\ncirclely = %20.12f',eval(tcirclely));
fprintf(fid,'\n');

```

```

syms r1 th1 px1 pyl pz1;

```

```

px1 = 0.0;
pyl = 0.0;
pz1 = 0.0;
th1 = 0.0;
r1 = 2;
ar1 = [r1^4 r1^3 r1^2 r1^1];
br1 = [real(eval(dBznap)/eval(r1lap))];
l = 8;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1];
br1 = [br1; real(eval(dBznap)/eval(r1lap))];
r1 = 16;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1];

```

```

br1 = [br1; real(eval(dBznap)/eval(rllap))];
r1 = 48;
ar1 = [ar1; r1^4 r1^3 r1^2 r1^1];
br1 = [br1; real(eval(dBznap)/eval(rllap))];
coefr1 = pinv(ar1)*real(br1);
disp('coefr1...');
px1 = 0.0;
py1 = 0.0;
pz1 = 0.0;
r1 = 1.0;
th1 = 3.14159/2;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1];
br1 = [real(eval(dBznap)/eval(rllap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1];
th1 = 3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1];
br1 = [br1; real(eval(dBznap)/eval(rllap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*
r1^2 - coefr1(4)*r1^1];
th1 = 3*3.14159/2;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1];
br1 = [br1; real(eval(dBznap)/eval(rllap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*
r1^2 - coefr1(4)*r1^1];
th1 = 2*3.14159;
ar1 = [ar1; th1^4 th1^3 th1^2 th1^1];
br1 = [br1; real(eval(dBznap)/eval(rllap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*
r1^2 - coefr1(4)*r1^1];
coefr2 = pinv(ar1)*real(br1);
disp('coefr2...');
py1 = 0.0;
pz1 = 0.0;
r1 = 1.0;
th1 = 0.0;
px1 = 2;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1];
atmp = real(eval(dBznap)/eval(rllap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
br1 = [atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1];
px1 = 8;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1];
atmp = real(eval(dBznap)/eval(rllap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^
1];
px1 = 18;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1];
atmp = real(eval(dBznap)/eval(rllap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^
1];
px1 = 48;
ar1 = [ar1; px1^4 px1^3 px1^2 px1^1];
atmp = real(eval(dBznap)/eval(rllap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
br1 = [br1; atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^
1];
coefr3 = pinv(ar1)*real(br1);
disp('coefr3...');
px1 = 0.0;
pz1 = 0.0;
r1 = 1.0;
th1 = 0.0;
py1 = 2;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1];
atmp = real(eval(dBznap)/eval(rllap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;

```

```

br1 = [atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;];
py1 = 8;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = real(eval(dBznap)/eval(rllap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^
1;];
py1 = 16;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = real(eval(dBznap)/eval(rllap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^
1;];
py1 = 64;
ar1 = [ar1; py1^4 py1^3 py1^2 py1^1;];
atmp = real(eval(dBznap)/eval(rllap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
br1 = [br1; atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^
1;];
coefr4 = pinv(ar1)*real(br1);
disp('coefr4...');
px1 = 0.0;
py1 = 0.0;
r1 = 1.0;
th1 = 0.0;
pz1 = 2;
ar1 = [pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = real(eval(dBznap)/eval(rllap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^1;];
pz1 = 8;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = real(eval(dBznap)/eval(rllap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^
1;];
pz1 = 32;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = real(eval(dBznap)/eval(rllap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^
1;];
pz1 = 48;
ar1 = [ar1; pz1^4 pz1^3 pz1^2 pz1^1;];
atmp = real(eval(dBznap)/eval(rllap)) - coefr1(1)*r1^4 - coefr1(2)*r1^3 - coefr1(3)*r1^2 -
coefr1(4)*r1^1;
atmp = atmp - coefr2(1)*th1^4 - coefr2(2)*th1^3 - coefr2(3)*th1^2 - coefr2(4)*th1^1;
atmp = atmp - coefr3(1)*px1^4 - coefr3(2)*px1^3 - coefr3(3)*px1^2 - coefr3(4)*px1^1;
br1 = [br1; atmp - coefr4(1)*py1^4 - coefr4(2)*py1^3 - coefr4(3)*py1^2 - coefr4(4)*py1^
1;];
coefr5 = pinv(ar1)*real(br1);
disp('coefr5...');
yms r1 th1 px1 py1 pz1;
dBz = coefr1(1)*r1^4 + coefr1(2)*r1^3 + coefr1(3)*r1^2 + coefr1(4)*r1^1;
dBz = dBz + coefr2(1)*th1^4 + coefr2(2)*th1^3 + coefr2(3)*th1^2 + coefr2(4)*th1^1;
dBz = dBz + coefr3(1)*px1^4 + coefr3(2)*px1^3 + coefr3(3)*px1^2 + coefr3(4)*px1^1;
dBz = dBz + coefr4(1)*py1^4 + coefr4(2)*py1^3 + coefr4(3)*py1^2 + coefr4(4)*py1^1;

```

```
dBz = dBz + coefr5(1)*pz1^4 + coefr5(2)*pz1^3 + coefr5(3)*pz1^2 + coefr5(4)*pz1^1;
disp('dBz...');
```

```
1 = 1.0;
```

```
circle1z = u0*int(dBz,th1,0,2*3.14159);
disp('finished circle1z...');
```

```
fprintf(fid,'\n\nCircle1z = Sum of: \n');
```

```
for il = 1:4
```

```
    fprintf(fid,'%20.12f',coefr1(il));
```

```
    fprintf(fid,' px1^%li',il);
```

```
    fprintf(fid,'\n');
```

```
end
```

```
for il = 1:4
```

```
    fprintf(fid,'%20.12f',coefr2(il));
```

```
    fprintf(fid,' py1^%li',il);
```

```
    fprintf(fid,'\n');
```

```
end
```

```
for il = 1:4
```

```
    fprintf(fid,'%20.12f',coefr3(il));
```

```
    fprintf(fid,' pz1^%li',il);
```

```
    fprintf(fid,'\n');
```

```
end
```

```
for il = 1:4
```

```
    fprintf(fid,'%20.12f',coefr4(il));
```

```
    fprintf(fid,' th1^%li',il);
```

```
    fprintf(fid,'\n');
```

```
end
```

```
for il = 1:4
```

```
    fprintf(fid,'%20.12f',coefr5(il));
```

```
    fprintf(fid,' th2^%li',il);
```

```
    fprintf(fid,'\n');
```

```
end
```

```
syms test1 test2 test3 test4 test5;
```

```
tcircle1z = coefr1(1)*test1^4 + coefr1(2)*test1^3 + coefr1(3)*test1^2 + coefr1(4)*test1^1;
tcircle1z = tcircle1z + coefr2(1)*test2^4 + coefr2(2)*test2^3 + coefr2(3)*test2^2 + coefr2(4)*test2^1;
```

```
tcircle1z = tcircle1z + coefr3(1)*test3^4 + coefr3(2)*test3^3 + coefr3(3)*test3^2 + coefr3(4)*test3^1;
```

```
tcircle1z = tcircle1z + coefr4(1)*test4^4 + coefr4(2)*test4^3 + coefr4(3)*test4^2 + coefr4(4)*test4^1;
```

```
tcircle1z = tcircle1z + coefr5(1)*test5^4 + coefr5(2)*test5^3 + coefr5(3)*test5^2 + coefr5(4)*test5^1;
```

```
test1 = 2*r1;
```

```
test2 = 0.0;
```

```
test3 = 0.0;
```

```
test4 = 0.0;
```

```
test5 = 0.0;
```

```
fprintf(fid,'\n\nTest of circle1z:');
```

```
fprintf(fid,'\npx1 = %20.12f',test1);
```

```
fprintf(fid,'\npy1 = %20.12f',test2);
```

```
fprintf(fid,'\npz1 = %20.12f',test3);
```

```
fprintf(fid,'\nth1 = %20.12f',test4);
```

```
fprintf(fid,'\nth2 = %20.12f',test5);
```

```
fprintf(fid,'\ncircle1z = %20.12f',eval(tcircle1z));
```

```
fprintf(fid,'\n');
```

```
syms r1 th1 px1 py1 pz1;
```

```
%; dBx = diff(y2)*r1z - r1y*diff(z2)/r11^2;
```

```
%; dBy = diff(x2)*r1z - r1x*diff(z2)/r11^2;
```

```
%; dBz = diff(x2)*r1y - r1x*diff(y2)/r11^2;
```

```

disp('finished symbolic computation of dB...');

%;fprintf(fid,'\ndBx = ');
%;fprintf(fid,char(dBx));
%;fprintf(fid,'\ndBy = ');
%;fprintf(fid,char(dBy));
%;fprintf(fid,'\ndBz = ');
%;fprintf(fid,char(dBz));
%;fprintf(fid,'\n');
%;disp('finished symbolic computation of dBx, dby, dBz...');
%;

%;
%; This next section takes too long, so it has to be converted into polynomial matrices
%;

pxlt = pxl;
pylt = pyl;
pzlt = pzl;
thlt = thl;
th2t = th2;

%;
%; compute the torus equation
%; - Rt = radius of torus
%; - Ot = origin of torus
%; - Or = origin of ring
%; - Tht = angle of ring in x-y plane
%; - Thtn = angle of torus in x-y plane
%; - ...coordinates in torus
%; - 28 points generated by for loop to 28 points generated by loop
%; - looking for a 28x28 matrix to multiply each point by...
%; - Therefor you need 28 matrices to have a solution for each row
%; - Now use this matrix to generate the cumulative torus equation
%; - ...with a for loop on the individual equations
%;

%;
%;
%;
syms thcum rpt xpt ypt thpt Rt Otx Oty Otz Or Tht nr thp toruslx torusly toruslz;
syms coef6 coef7 coef8 coef9 coef10 coef11 coef12 coef13 coef14 toruseqlx toruseqly
toruseqlz;
syms k1 k2 k3 k4 tmp1 Thtn thT;
syms Rtt Ottx Otyt Otzt Thtt Thnt;

r1 = 1.0;
Otx = 0;
Oty = 0;
Otz = 0;
xpt = Otx + Rt*cos(Tht);
ypt = Oty + Rt*sin(Tht);
rpt = sqrt((xpt - Otx)^2 + (ypt - Oty)^2);
xt = Otx + Rt*cos(Tht);
yt = Oty + Rt*sin(Tht);

```

```

% thpt = atan1(xt,yt);
syms thpt;
thcum = thpt + Thtn;
x0 = rpt*cos(thcum);
y0 = rpt*sin(thcum);
th1 = Tht;
th2 = 0;
nr = 8;
thp = 2*3.14159/nr;
Tht = thp*i1;
Rt = 20;
torus1x = 0;
for i1 = 1:nr
    thpt= atan1(eval(xt),eval(yt));
    torus1x = torus1x + circle1x;
end
a1 = [Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [eval(torus1x);];
Rt = 60;
torus1x = 0;
for i1 = 1:nr
    thpt= atan1(eval(xt),eval(yt));
    torus1x = torus1x + circle1x;
end
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [b1; eval(torus1x);];
Rt = 240;
torus1x = 0;
for i1 = 1:nr
    thpt= atan1(eval(xt),eval(yt));
    torus1x = torus1x + circle1x;
end
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^2;];
b1 = [b1; eval(torus1x);];
Rt = 2400;
torus1x = 0;
for i1 = 1:nr
    thpt= atan1(eval(xt),eval(yt));
    torus1x = torus1x + circle1x;
end
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^2;];
b1 = [b1; eval(torus1x);];
%
% The following is the first set of coefficients of the torus equation for Rt = variable
%
coef6 = pinv(a1)*b1;
disp('coef6...');
x0 = Otx + Rt*cos(Tht);
y0 = Oty + Rt*sin(Tht);
th1 = Tht;
nr = 8;
thp = 2*3.14159/nr;
Tht = thp*i1;
Rt = 20;
Otx = 8*r1;
torus1x = 0;
for i1 = 1:nr
    torus1x = torus1x + circle1x;
end
a1 = [Otx^4 Otx^3 Otx^2 Otx^1;];
b1 = [(eval(torus1x) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1);];
Otx = 64*r1;
torus1x = 0;
for i1 = 1:nr
    torus1x = torus1x + circle1x;
end

```

```

a1 = [a1; Otx^4 Otx^3 Otx^2 Otx^1;];
b1 = [b1; (eval(torus1x) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1);];
Otx = -8*r1;
torus1x = 0;
for il = 1:nr
    torus1x = torus1x + circle1x;
end
a1 = [a1; Otx^4 Otx^3 Otx^2 Otx^1;];
b1 = [b1; (eval(torus1x) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1);];
Otx = -64*r1;
torus1x = 0;
for il = 1:nr
    torus1x = torus1x + circle1x;
end
a1 = [a1; Otx^4 Otx^3 Otx^2 Otx^1;];
b1 = [b1; (eval(torus1x) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1);];

%;
%; The following is the first set of coefficients of the torus equation for Rt = 20, Otx =
variable
%;
coef7 = pinv(a1)*b1;
disp('coef7...');
x0 = Otx + Rt*cos(Tht);
y0 = Oty + Rt*sin(Tht);
th1 = Tht;
nr = 8;
thp = 2*3.14159/nr;
Tht = thp*il;
Rt = 20;
Otx = 0;
Oty = 8*r1;
torus1x = 0;
for il = 1:nr
    torus1x = torus1x + circle1x;
end
a1 = [Oty^4 Oty^3 Oty^2 Oty^1;];
tmp = eval(torus1x) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
b1 = [tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;];
Oty = 64*r1;
torus1x = 0;
for il = 1:nr
    torus1x = torus1x + circle1x;
end
a1 = [a1; Oty^4 Oty^3 Oty^2 Oty^1;];
tmp = eval(torus1x) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
b1 = [b1; tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;];
Oty = -8*r1;
torus1x = 0;
for il = 1:nr
    torus1x = torus1x + circle1x;
end
a1 = [a1; Oty^4 Oty^3 Oty^2 Oty^1;];
tmp = eval(torus1x) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
b1 = [b1; tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;];
Oty = -64*r1;
torus1x = 0;
for il = 1:nr
    torus1x = torus1x + circle1x;
end
a1 = [a1; Oty^4 Oty^3 Oty^2 Oty^1;];
tmp = eval(torus1x) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
b1 = [b1; tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;];

```

```

% ;
% ; The following is the first set of coefficients of the torus equation for Rt = 20, Otx =
0, Oty = variable
% ;
coef8 = pinv(a1)*b1;
disp('coef8...');
x0 = Otx + Rt*cos(Tht);
y0 = Oty + Rt*sin(Tht);
th1 = Tht;
nr = 8;
thp = 2*3.14159/nr;
Tht = thp*il;
Rt = 20;
Otx = 0;
Oty = 0;
otz = 8*r1;
toruslx = 0;
for il = 1:nr
    toruslx = toruslx + circlelx;
end
a1 = [Otz^4 Otz^3 Otz^2 Otz^1;];
tmp = eval(toruslx) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
tmp = tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;
b1 = [tmp - coef8(1)*Oty^4 - coef8(2)*Oty^3 - coef8(3)*Oty^2 - coef8(4)*Oty^1;];
Otz = 64*r1;
toruslx = 0;
for il = 1:nr
    toruslx = toruslx + circlelx;
end
a1 = [a1; Otz^4 Otz^3 Otz^2 Otz^1;];
tmp = eval(toruslx) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
tmp = tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;
b1 = [b1; tmp - coef8(1)*Oty^4 - coef8(2)*Oty^3 - coef8(3)*Oty^2 - coef8(4)*Oty^1;];
Otz = -8*r1;
toruslx = 0;
for il = 1:nr
    toruslx = toruslx + circlelx;
end
a1 = [a1; Otz^4 Otz^3 Otz^2 Otz^1;];
tmp = eval(toruslx) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
tmp = tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;
b1 = [b1; tmp - coef8(1)*Oty^4 - coef8(2)*Oty^3 - coef8(3)*Oty^2 - coef8(4)*Oty^1;];
Otz = -64*r1;
toruslx = 0;
for il = 1:nr
    toruslx = toruslx + circlelx;
end
a1 = [a1; Otz^4 Otz^3 Otz^2 Otz^1;];
tmp = eval(toruslx) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
tmp = tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;
b1 = [b1; tmp - coef8(1)*Oty^4 - coef8(2)*Oty^3 - coef8(3)*Oty^2 - coef8(4)*Oty^1;];

% ;
% ; The following is the first set of coefficients of the torus equation for Rt = 20, Otx =
0, Oty = 0, Otz = var.
% ;
coef9 = pinv(a1)*b1;
disp('coef9...');
% ;
x0 = Otx + Rt*cos(Tht);
y0 = Oty + Rt*sin(Tht);
th1 = Tht;
nr = 8;
thp = 2*3.14159/nr;
Tht = thp*il;

```



```

k1 = 10;
k2 = 2;
k3 = 2;
k4 = -2;
t = k1*r1;
Otx = k2*r1;
Oty = k3*r1;
Otz = k4*r1;
px1 = 2*r1;
toruslx = 0;
for il = 1:nr
    toruslx = toruslx + circlelx;
end
a1 = [px1^4 px1^3 px1^2 px1^1;];
tmp1 = eval(toruslx) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
tmp1 = tmp1 - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;
tmp1 = tmp1 - coef8(1)*Oty^4 - coef8(2)*Oty^3 - coef8(3)*Oty^2 - coef8(4)*Oty^1;
tmp1 = tmp1 - coef9(1)*Otz^4 - coef9(2)*Otz^3 - coef9(3)*Otz^2 - coef9(4)*Otz^1;

b1 = [tmp1;];
px1 = 8*r1;
toruslx = 0;
for il = 1:nr
    toruslx = toruslx + circlelx;
end
a1 = [a1; px1^4 px1^3 px1^2 px1^1;];
b1 = [b1; tmp1;];
px1 = 32*r1;
toruslx = 0;
for il = 1:nr
    toruslx = toruslx + circlelx;
end
a1 = [a1; px1^4 px1^3 px1^2 px1^1;];
b1 = [b1; tmp1;];
px1 = 200*r1;
toruslx = 0;
for il = 1:nr
    toruslx = toruslx + circlelx;
end
a1 = [a1; px1^4 px1^3 px1^2 px1^1;];
b1 = [b1; tmp1;];
%;
%; coefficients of the torus equation for (...) px1 = variable
%;
coef10 = pinv(a1)*b1;
disp('coef10...');

px1 = 2*r1;
py1 = 2*r1;
toruslx = 0;
for il = 1:nr
    toruslx = toruslx + circlelx;
end
a1 = [py1^4 py1^3 py1^2 py1^1;];
b1 = [tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;];
py1 = 8*r1;
toruslx = 0;
for il = 1:nr
    toruslx = toruslx + circlelx;
end
a1 = [a1; py1^4 py1^3 py1^2 py1^1;];
b1 = [b1; tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;];
py1 = 32*r1;
toruslx = 0;
for il = 1:nr
    toruslx = toruslx + circlelx;

```

```

end
a1 = [a1; py1^4 py1^3 py1^2 py1^1;];
b1 = [b1; tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;];
py1 = 200*r1;
torus1x = 0;
for i1 = 1:nr
    torus1x = torus1x + circle1x;
end
a1 = [a1; py1^4 py1^3 py1^2 py1^1;];
b1 = [b1; tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;];
%;
%; coefficients of the torus equation for (...) py1 = variable
%;
coef11 = pinv(a1)*b1;
disp('coef11...');
px1 = 2*r1;
py1 = 2*r1;
pz1 = 2*r1;
torus1x = 0;
for i1 = 1:nr
    torus1x = torus1x + circle1x;
end
a1 = [pz1^4 pz1^3 pz1^2 pz1^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
b1 = [tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;];
pz1 = 8*r1;
torus1x = 0;
for i1 = 1:nr
    torus1x = torus1x + circle1x;
end
a1 = [a1; pz1^4 pz1^3 pz1^2 pz1^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
b1 = [b1; tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;];
pz1 = 32*r1;
torus1x = 0;
for i1 = 1:nr
    torus1x = torus1x + circle1x;
end
a1 = [a1; pz1^4 pz1^3 pz1^2 pz1^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
b1 = [b1; tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;];
pz1 = 200*r1;
torus1x = 0;
for i1 = 1:nr
    torus1x = torus1x + circle1x;
end
a1 = [a1; pz1^4 pz1^3 pz1^2 pz1^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
b1 = [b1; tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;];
%;
%; coefficients of the torus equation for (...) pz1 = variable
%;
coef12 = pinv(a1)*b1;
disp('coef12...');
px1 = 2*r1;
py1 = 2*r1;
pz1 = 2*r1;
Th1 = 3.14159/2;
torus1x = 0;
for i1 = 1:nr
    torus1x = torus1x + circle1x;
end
a1 = [Th1^4 Th1^3 Th1^2 Th1^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;

```

```

b1 = [tmp - coef12(1)*pz1^4 - coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;];
Tht = 3.14159;
toruslx = 0;
for il = 1:nr
    toruslx = toruslx + circle1lx;
end
a1 = [a1; Tht^4 Tht^3 Tht^2 Tht^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
b1 = [b1; tmp - coef12(1)*pz1^4 - coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;];
Tht = 3*3.14159/2;
toruslx = 0;
for il = 1:nr
    toruslx = toruslx + circle1lx;
end
a1 = [a1; Tht^4 Tht^3 Tht^2 Tht^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
b1 = [b1; tmp - coef12(1)*pz1^4 - coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;];
Tht = 2*3.14159;
toruslx = 0;
for il = 1:nr
    toruslx = toruslx + circle1lx;
end
a1 = [a1; Tht^4 Tht^3 Tht^2 Tht^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
b1 = [b1; tmp - coef12(1)*pz1^4 - coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;];

%;
%; coefficients of the torus equation for (...) Tht = variable
%;
coef13 = pinv(a1)*b1;
disp('coef13...');
px1 = 2*r1;
py1 = 2*r1;
pz1 = 2*r1;
Tht = 0.0;
Thtn = 3.14159/2;
toruslx = 0;
for il = 1:nr
    toruslx = toruslx + circle1lx;
end
a1 = [Thtn^4 Thtn^3 Thtn^2 Thtn^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
tmp = tmp - coef12(1)*pz1^4 - coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;
b1 = [tmp - coef13(1)*Tht^4 - coef13(2)*Tht^3 - coef13(3)*Tht^2 - coef13(4)*Tht^1;];
Thtn = 3.14159;
toruslx = 0;
for il = 1:nr
    toruslx = toruslx + circle1lx;
end
a1 = [a1; Thtn^4 Thtn^3 Thtn^2 Thtn^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
tmp = tmp - coef12(1)*pz1^4 - coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;
b1 = [b1; tmp - coef13(1)*Tht^4 - coef13(2)*Tht^3 - coef13(3)*Tht^2 - coef13(4)*Tht^1;];
Thtn = 3*3.14159/2;
toruslx = 0;
for il = 1:nr
    toruslx = toruslx + circle1lx;
end
a1 = [a1; Thtn^4 Thtn^3 Thtn^2 Thtn^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;

```

```

tmp = tmp - coef12(1)*pz1^4 - coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;
b1 = [b1; tmp - coef13(1)*Tht^4 - coef13(2)*Tht^3 - coef13(3)*Tht^2 - coef13(4)*Tht^1;];
Thtn = 2*3.14159;
torus1x = 0;
    or il = 1:nr
        torus1x = torus1x + circle1x;
end
a1 = [a1; Thtn^4 Thtn^3 Thtn^2 Thtn^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
tmp = tmp - coef12(1)*pz1^4 - coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;
b1 = [b1; tmp - coef13(1)*Tht^4 - coef13(2)*Tht^3 - coef13(3)*Tht^2 - coef13(4)*Tht^1;];

%;
%; coefficients of the torus equation for (...) Thtn = variable
%;
coef14 = pinv(a1)*b1;
disp('coef14...');

%;
%; Now, finally the complete torus equation
%;

coef6 = eval(coef6);
coef7 = eval(coef7);
coef8 = eval(coef8);
coef9 = eval(coef9);
coef10 = eval(coef10);
coef11 = eval(coef11);
coef12 = eval(coef12);
coef13 = eval(coef13);
coef14 = eval(coef14);

yms Rtt Ottx Otty Otzt pxlt pylt pzlt Thtt Thnt;

toruseqlx = coef6(1)*Rtt^4 + coef6(2)*Rtt^3 + coef6(3)*Rtt^2 + coef6(4)*Rtt^1;
toruseqlx = toruseqlx + coef7(1)*Ottx^4 + coef7(2)*Ottx^3 + coef7(3)*Ottx^2 + coef7(4)
*Ottx^1;
toruseqlx = toruseqlx + coef8(1)*Otty^4 + coef8(2)*Otty^3 + coef8(3)*Otty^2 + coef8(4)
*Otty^1;
toruseqlx = toruseqlx + coef9(1)*Otzt^4 + coef9(2)*Otzt^3 + coef9(3)*Otzt^2 + coef9(4)
*Otzt^1;
toruseqlx = toruseqlx + coef10(1)*pxlt^4 + coef10(2)*pxlt^3 + coef10(3)*pxlt^2 + coef10(4)
*pxlt^1;
toruseqlx = toruseqlx + coef11(1)*pylt^4 + coef11(2)*pylt^3 + coef11(3)*pylt^2 + coef11(4)
*pylt^1;
toruseqlx = toruseqlx + coef12(1)*pzlt^4 + coef12(2)*pzlt^3 + coef12(3)*pzlt^2 + coef12(4)
*pzlt^1;
toruseqlx = toruseqlx + coef13(1)*Thtt^4 + coef13(2)*Thtt^3 + coef13(3)*Thtt^2 + coef13(4)
*Thtt^1;
toruseqlx = toruseqlx + coef14(1)*Thnt^4 + coef14(2)*Thnt^3 + coef14(3)*Thnt^2 + coef14
(4)*Thnt^1;
disp('finished computation of toruseqlx...');
fprintf(fid, '\n\ntoruseqlx = Sum of: \n');
for il = 1:4
    fprintf(fid, '%20.12f', coef6(il));
    fprintf(fid, ' Rtt^%1i', il);
    fprintf(fid, '\n');
end
for il = 1:4
    fprintf(fid, '%20.12f', coef7(il));
    fprintf(fid, ' Ottx^%1i', il);
    fprintf(fid, '\n');
end
for il = 1:4
    fprintf(fid, '%20.12f', coef8(il));

```

```

    fprintf(fid,' Otyt^%li',i1);
    fprintf(fid,'\n');
end
for i1 = 1:4
    fprintf(fid,'%20.12f',coef9(i1));
    fprintf(fid,' Otzt^%li',i1);
    fprintf(fid,'\n');
end
for i1 = 1:4
    fprintf(fid,'%20.12f',coef10(i1));
    fprintf(fid,' pxlt^%li',i1);
    fprintf(fid,'\n');
end
for i1 = 1:4
    fprintf(fid,'%20.12f',coef11(i1));
    fprintf(fid,' pylt^%li',i1);
    fprintf(fid,'\n');
end
for i1 = 1:4
    fprintf(fid,'%20.12f',coef12(i1));
    fprintf(fid,' pzlt^%li',i1);
    fprintf(fid,'\n');
end
for i1 = 1:4
    fprintf(fid,'%20.12f',coef13(i1));
    fprintf(fid,' Thtt^%li',i1);
    fprintf(fid,'\n');
end
for i1 = 1:4
    fprintf(fid,'%20.12f',coef14(i1));
    fprintf(fid,' Thtnt^%li',i1);
    fprintf(fid,'\n');
end
fprintf(fid,'\n\nTest of torus1x');
Rtt = 5.0;
Otxt = 0.0;
Otyt = 0.0;
Otzt = 0.0;
pxlt = 0.0;
pylt = 0.0;
pzlt = 0.0;
Thtt = 0.0;
Thtnt = 0.0;
fprintf(fid,'\nRtt = %20.12f',Rtt);
fprintf(fid,'\nOtx = %20.12f',Otxt);
fprintf(fid,'\nOty = %20.12f',Otyt);
fprintf(fid,'\nOtz = %20.12f',Otzt);
fprintf(fid,'\npxlt = %20.12f',pxlt);
fprintf(fid,'\npylt = %20.12f',pylt);
fprintf(fid,'\npzlt = %20.12f',pzlt);
fprintf(fid,'\nThtt = %20.12f',Thtt);
fprintf(fid,'\nThtnt = %20.12f',Thtnt);
fprintf(fid,'\ntorus1x = %20.12f',eval(torus1x));
fprintf(fid,'\n');
fprintf(fid,'\n\nTest of torus1x');
Rtt = 5.0;
Otxt = 0.0;
Otyt = 0.0;
Otzt = 0.0;
pxlt = 10.0;
pylt = 0.0;
pzlt = 0.0;
Thtt = 0.0;
Thtnt = 0.0;
fprintf(fid,'\nRtt = %20.12f',Rtt);

```

```

fprintf(fid, '\nOtx = %20.12f', Otx);
fprintf(fid, '\nOty = %20.12f', Oty);
fprintf(fid, '\nOtz = %20.12f', Otzt);
fprintf(fid, '\npxlt = %20.12f', pxlt);
fprintf(fid, '\npylt = %20.12f', pylt);
fprintf(fid, '\npzlt = %20.12f', pzlt);
fprintf(fid, '\nThtt = %20.12f', Thtt);
fprintf(fid, '\nThtnt = %20.12f', Thtnt);
fprintf(fid, '\ntoruslx = %20.12f', eval(toruslx));
fprintf(fid, '\n');
fprintf(fid, '\n\nTest of toruslx');
Rtt = 5.0;
Otx = 0.0;
Oty = 0.0;
Otzt = 0.0;
pxlt = 0.0;
pylt = 0.0;
pzlt = 10.0;
Thtt = 0.0;
Thtnt = 0.0;
fprintf(fid, '\nRtt = %20.12f', Rtt);
fprintf(fid, '\nOtx = %20.12f', Otx);
fprintf(fid, '\nOty = %20.12f', Oty);
fprintf(fid, '\nOtz = %20.12f', Otzt);
fprintf(fid, '\npxlt = %20.12f', pxlt);
fprintf(fid, '\npylt = %20.12f', pylt);
fprintf(fid, '\npzlt = %20.12f', pzlt);
fprintf(fid, '\nThtt = %20.12f', Thtt);
fprintf(fid, '\nThtnt = %20.12f', Thtnt);
fprintf(fid, '\ntoruslx = %20.12f', eval(toruslx));
fprintf(fid, '\n');
fprintf(fid, '\n\nTest of toruslx');
Rtt = 5.0;
Otx = 0.0;
Oty = 0.0;
Otzt = 0.0;
pxlt = -10.0;
pylt = 0.0;
pzlt = 0.0;
Thtt = 0.0;
Thtnt = 0.0;
fprintf(fid, '\nRtt = %20.12f', Rtt);
fprintf(fid, '\nOtx = %20.12f', Otx);
fprintf(fid, '\nOty = %20.12f', Oty);
fprintf(fid, '\nOtz = %20.12f', Otzt);
fprintf(fid, '\npxlt = %20.12f', pxlt);
fprintf(fid, '\npylt = %20.12f', pylt);
fprintf(fid, '\npzlt = %20.12f', pzlt);
fprintf(fid, '\nThtt = %20.12f', Thtt);
fprintf(fid, '\nThtnt = %20.12f', Thtnt);
fprintf(fid, '\ntoruslx = %20.12f', eval(toruslx));
fprintf(fid, '\n');
fprintf(fid, '\n\nTest of toruslx');
Rtt = 5.0;
Otx = 0.0;
Oty = 0.0;
Otzt = 0.0;
pxlt = 0.0;
pylt = 0.0;
pzlt = -10.0;
Thtt = 0.0;
Thtnt = 0.0;
fprintf(fid, '\nRtt = %20.12f', Rtt);
fprintf(fid, '\nOtx = %20.12f', Otx);
fprintf(fid, '\nOty = %20.12f', Oty);
fprintf(fid, '\nOtz = %20.12f', Otzt);

```

```

fprintf(fid, '\npxlt = %20.12f', pxlt);
fprintf(fid, '\npylt = %20.12f', pylt);
fprintf(fid, '\npzlt = %20.12f', pzlt);
fprintf(fid, '\nThtt = %20.12f', Thtt);
fprintf(fid, '\nThtnt = %20.12f', Thtnt);
fprintf(fid, '\ntoruslx = %20.12f', eval(toruslx));
fprintf(fid, '\nr');

```

```

syms coef6 coef7 coef8 coef9 coef10 coef11 coef12 coef13 coef14;

```

```

r1 = 1.0;
Otx = 0;
Oty = 0;
Otz = 0;
xpt = Otx + Rt*cos(Tht);
ypt = Oty + Rt*sin(Tht);
rpt = sqrt((xpt - Otx)^2 + (ypt - Oty)^2);
xt = xpt;
yt = ypt;
%; thpt = itan1(xt, yt);
syms thpt;
thcum = thpt + Thtn;
x0 = rpt*cos(thcum);
y0 = rpt*sin(thcum);
th1 = Tht;
th2 = 0;
nr = 8;
thp = 2*3.14159/nr;
Tht = thp*il;
torusly = 0;
Rt = 20;

```

```

for il = 1:nr
    thpt = itan1(xt, yt);
    torusly = torusly + circlely;
end

```

```

a1 = [Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [eval(toruslx);];
Rt = 60;

```

```

for il = 1:nr
    thpt = itan1(xt, yt);
    torusly = torusly + circlely;
end

```

```

a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [b1; eval(torusly);];
Rt = 240;

```

```

for il = 1:nr
    thpt = itan1(xt, yt);
    torusly = torusly + circlely;
end

```

```

a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^2;];
b1 = [b1; eval(torusly);];
Rt = 2400;

```

```

for il = 1:nr
    thpt = itan1(xt, yt);
    torusly = torusly + circlely;
end

```

```

a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^2;];
b1 = [b1; eval(torusly);];
%;

```

```

%; The following is the first set of coefficients of the torus equation for Rt = variable
%;

```

```

coef6 = pinv(a1)*b1;
disp('coef6...');
x0 = Otx + Rt*cos(Tht);

```

```

y0 = Oty + Rt*sin(Tht);
th1 = Tht;
nr = 8;
thp = 2*3.14159/nr;
tht = thp*il;
Rt = 20;
Otx = 8*r1;
torusly = 0;
for il = 1:nr
    torusly = torusly + circlely;
end
a1 = [Otx^4 Otx^3 Otx^2 Otx^1;];
b1 = [(eval(torusly) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1);];
Otx = 64*r1;
torusly = 0;
for il = 1:nr
    torusly = torusly + circlely;
end
a1 = [a1; Otx^4 Otx^3 Otx^2 Otx^1;];
b1 = [b1; (eval(torusly) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1);];
Otx = -8*r1;
torusly = 0;
for il = 1:nr
    torusly = torusly + circlely;
end
a1 = [a1; Otx^4 Otx^3 Otx^2 Otx^1;];
b1 = [b1; (eval(torusly) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1);];
Otx = -64*r1;
torusly = 0;
for il = 1:nr
    torusly = torusly + circlely;
end
a1 = [a1; Otx^4 Otx^3 Otx^2 Otx^1;];
b1 = [b1; (eval(torusly) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1);];

%;
%; The following is the first set of coefficients of the torus equation for Rt = 20, Otx =
variable
%;
coef7 = pinv(a1)*b1;
disp('coef7...');
x0 = Otx + Rt*cos(Tht);
y0 = Oty + Rt*sin(Tht);
th1 = Tht;
nr = 8;
thp = 2*3.14159/nr;
Tht = thp*il;
Rt = 20;
Otx = 0;
Oty = 8*r1;
torusly = 0;
for il = 1:nr
    torusly = torusly + circlely;
end
a1 = [Oty^4 Oty^3 Oty^2 Oty^1;];
tmp = eval(torusly) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
b1 = [tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;];
Oty = 64*r1;
torusly = 0;
for il = 1:nr
    torusly = torusly + circlely;
end
a1 = [a1; Oty^4 Oty^3 Oty^2 Oty^1;];

```



```

tmp = eval(torusly) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
b1 = [b1; tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;];
Oty = -8*r1;
torusly = 0;
    or il = 1:nr
        torusly = torusly + circlely;
    end
a1 = [a1; Oty^4 Oty^3 Oty^2 Oty^1;];
tmp = eval(torusly) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
b1 = [b1; tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;];
Oty = -64*r1;
torusly = 0;
for il = 1:nr
    torusly = torusly + circlely;
end
a1 = [a1; Oty^4 Oty^3 Oty^2 Oty^1;];
tmp = eval(torusly) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
b1 = [b1; tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;];

%;
%; The following is the first set of coefficients of the torus equation for Rt = 20, Otx =
0, Oty = variable
%;
coef8 = pinv(a1)*b1;
disp('coef8...');
x0 = Otx + Rt*cos(Tht);
y0 = Oty + Rt*sin(Tht);
th1 = Tht;
nr = 8;
thp = 2*3.14159/nr;
Tht = thp*il;
Rt = 20;
Otx = 0;
Oty = 0;
Otz = 8*r1;
torusly = 0;
for il = 1:nr
    torusly = torusly + circlely;
end
a1 = [Otz^4 Otz^3 Otz^2 Otz^1;];
tmp = eval(torusly) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
tmp = tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;
b1 = [tmp - coef8(1)*Oty^4 - coef8(2)*Oty^3 - coef8(3)*Oty^2 - coef8(4)*Oty^1;];
Otz = 64*r1;
torusly = 0;
for il = 1:nr
    torusly = torusly + circlely;
end
a1 = [a1; Otz^4 Otz^3 Otz^2 Otz^1;];
tmp = eval(torusly) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
tmp = tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;
b1 = [b1; tmp - coef8(1)*Oty^4 - coef8(2)*Oty^3 - coef8(3)*Oty^2 - coef8(4)*Oty^1;];
Otz = -8*r1;
torusly = 0;
for il = 1:nr
    torusly = torusly + circlely;
end
a1 = [a1; Otz^4 Otz^3 Otz^2 Otz^1;];
tmp = eval(torusly) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
tmp = tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;
b1 = [b1; tmp - coef8(1)*Oty^4 - coef8(2)*Oty^3 - coef8(3)*Oty^2 - coef8(4)*Oty^1;];
Otz = -64*r1;
torusly = 0;
for il = 1:nr
    torusly = torusly + circlely;
end

```

```

a1 = [a1; Otx^4 Otx^3 Otx^2 Otx^1;];
tmp = eval(torusly) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
tmp = tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;
b1 = [b1; tmp - coef8(1)*Oty^4 - coef8(2)*Oty^3 - coef8(3)*Oty^2 - coef8(4)*Oty^1;];
%
%; The following is the first set of coefficients of the torus equation for Rt = 20, Otx =
0, Oty = 0, Otx = var.
%;
coef9 = pinv(a1)*b1;
disp('coef9...');
%;
x0 = Otx + Rt*cos(Tht);
y0 = Oty + Rt*sin(Tht);
th1 = Tht;
nr = 8;
thp = 2*3.14159/nr;
Tht = thp*i1;
Rt = k1*r1;
Otx = k2*r1;
Oty = k3*r1;
Otz = k4*r1;
px1 = 2*r1;
torusly = 0;
for i1 = 1:nr
    torusly = torusly + circlely;
end
a1 = [px1^4 px1^3 px1^2 px1^1;];
tmp1 = eval(torusly) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
tmp1 = tmp1 - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;
tmp1 = tmp1 - coef8(1)*Oty^4 - coef8(2)*Oty^3 - coef8(3)*Oty^2 - coef8(4)*Oty^1;
tmp1 = tmp1 - coef9(1)*Otz^4 - coef9(2)*Otz^3 - coef9(3)*Otz^2 - coef9(4)*Otz^1;

l = [tmp1;];
px1 = 8*r1;
torusly = 0;
for i1 = 1:nr
    torusly = torusly + circlely;
end

a1 = [a1; px1^4 px1^3 px1^2 px1^1;];
b1 = [b1; tmp1;];
px1 = 32*r1;
torusly = 0;
for i1 = 1:nr
    torusly = torusly + circlely;
end
a1 = [a1; px1^4 px1^3 px1^2 px1^1;];
b1 = [b1; tmp1;];
px1 = 200*r1;
torusly = 0;
for i1 = 1:nr
    torusly = torusly + circlely;
end
a1 = [a1; px1^4 px1^3 px1^2 px1^1;];
b1 = [b1; tmp1;];
%;
%; coefficients of the torus equation for (...) px1 = variable
%;
coef10 = pinv(a1)*b1;
disp('coef10...');

px1 = 2*r1;
py1 = 2*r1;
torusly = 0;
for i1 = 1:nr

```

```

    torusly = torusly + circlely;
end
a1 = [py1^4 py1^3 py1^2 py1^1;];
b1 = [tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;];
py1 = 8*r1;
torusly = 0;
for il = 1:nr
    torusly = torusly + circlely;
end
a1 = [a1; py1^4 py1^3 py1^2 py1^1;];
b1 = [b1; tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;];
py1 = 32*r1;
torusly = 0;
for il = 1:nr
    torusly = torusly + circlely;
end
a1 = [a1; py1^4 py1^3 py1^2 py1^1;];
b1 = [b1; tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;];
py1 = 200*r1;
torusly = 0;
for il = 1:nr
    torusly = torusly + circlely;
end
a1 = [a1; py1^4 py1^3 py1^2 py1^1;];
b1 = [b1; tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;];
%;
%; coefficients of the torus equation for (...) py1 = variable
%;
coef11 = pinv(a1)*b1;
disp('coef11...');
px1 = 2*r1;
py1 = 2*r1;
pz1 = 2*r1;
torusly = 0;
for il = 1:nr
    torusly = torusly + circlely;
end
a1 = [pz1^4 pz1^3 pz1^2 pz1^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
b1 = [tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;];
pz1 = 8*r1;
torusly = 0;
for il = 1:nr
    torusly = torusly + circlely;
end
a1 = [a1; pz1^4 pz1^3 pz1^2 pz1^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
b1 = [b1; tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;];
pz1 = 32*r1;
torusly = 0;
for il = 1:nr
    torusly = torusly + circlely;
end
a1 = [a1; pz1^4 pz1^3 pz1^2 pz1^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
b1 = [b1; tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;];
pz1 = 200*r1;
torusly = 0;
for il = 1:nr
    torusly = torusly + circlely;
end
a1 = [a1; pz1^4 pz1^3 pz1^2 pz1^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
b1 = [b1; tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;];
%;

```

```

% ; coefficients of the torus equation for (...) pz1 = variable
% ;
coef12 = pinv(a1)*b1;
disp('coef12...');
px1 = 2*r1;
py1 = 2*r1;
pz1 = 2*r1;
Tht = 3.14159/2;
torusly = 0;
for il = 1:nr
    torusly = torusly + circlely;
end
a1 = [Tht^4 Tht^3 Tht^2 Tht^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
b1 = [tmp - coef12(1)*pz1^4 - coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;];
Tht = 3.14159;
torusly = 0;
for il = 1:nr
    torusly = torusly + circlely;
end
a1 = [a1; Tht^4 Tht^3 Tht^2 Tht^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
b1 = [b1; tmp - coef12(1)*pz1^4 - coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;];
Tht = 3*3.14159/2;
torusly = 0;
for il = 1:nr
    torusly = torusly + circlely;
end
a1 = [a1; Tht^4 Tht^3 Tht^2 Tht^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
b1 = [b1; tmp - coef12(1)*pz1^4 - coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;];
Tht = 2*3.14159;
torusly = 0;
for il = 1:nr
    torusly = torusly + circlely;
end
a1 = [a1; Tht^4 Tht^3 Tht^2 Tht^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
b1 = [b1; tmp - coef12(1)*pz1^4 - coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;];

% ;
% ; coefficients of the torus equation for (...) Tht = variable
% ;
coef13 = pinv(a1)*b1;
disp('coef13...');
px1 = 2*r1;
py1 = 2*r1;
pz1 = 2*r1;
Tht = 0.0;
Thtn = 3.14159/2;
torusly = 0;
for il = 1:nr
    torusly = torusly + circlely;
end
a1 = [Thtn^4 Thtn^3 Thtn^2 Thtn^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
tmp = tmp - coef12(1)*pz1^4 - coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;
b1 = [tmp - coef13(1)*Tht^4 - coef13(2)*Tht^3 - coef13(3)*Tht^2 - coef13(4)*Tht^1;];
Thtn = 3.14159;
torusly = 0;
for il = 1:nr

```

```

torusly = torusly + circlely;
end
a1 = [a1; Thtn^4 Thtn^3 Thtn^2 Thtn^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
tmp = tmp - coef12(1)*pz1^4 - coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;
b1 = [b1; tmp - coef13(1)*Tht^4 - coef13(2)*Tht^3 - coef13(3)*Tht^2 - coef13(4)*Tht^1;];
Thtn = 3*3.14159/2;
torusly = 0;
for il = 1:nr
    torusly = torusly + circlely;
end
a1 = [a1; Thtn^4 Thtn^3 Thtn^2 Thtn^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
tmp = tmp - coef12(1)*pz1^4 - coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;
b1 = [b1; tmp - coef13(1)*Tht^4 - coef13(2)*Tht^3 - coef13(3)*Tht^2 - coef13(4)*Tht^1;];
Thtn = 2*3.14159;
torusly = 0;
for il = 1:nr
    torusly = torusly + circlely;
end
a1 = [a1; Thtn^4 Thtn^3 Thtn^2 Thtn^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
tmp = tmp - coef12(1)*pz1^4 - coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;
b1 = [b1; tmp - coef13(1)*Tht^4 - coef13(2)*Tht^3 - coef13(3)*Tht^2 - coef13(4)*Tht^1;];

%;
%; coefficients of the torus equation for (...) Thtn = variable
%;
coef14 = pinv(a1)*b1;
disp('coef14...');

%;
%; Now, finally the complete torus equation
%;

%;coef6 = eval(coef6);
%;coef7 = eval(coef7);
%;coef8 = eval(coef8);
%;coef9 = eval(coef9);
%;coef10 = eval(coef10);
%;coef11 = eval(coef11);
%;coef12 = eval(coef12);
%;coef13 = eval(coef13);
%;coef14 = eval(coef14);

syms Rtt Ottx Otty Otzt pxlt pylt pzlt thtt Thnt;

toruseqly = coef6(1)*Rtt^4 + coef6(2)*Rtt^3 + coef6(3)*Rtt^2 + coef6(4)*Rtt^1;
toruseqly = toruseqly + coef7(1)*Otx^4 + coef7(2)*Otx^3 + coef7(3)*Otx^2 + coef7(4)*Otx^1;
toruseqly = toruseqly + coef8(1)*Oty^4 + coef8(2)*Oty^3 + coef8(3)*Oty^2 + coef8(4)*Oty^1;
toruseqly = toruseqly + coef9(1)*Otz^4 + coef9(2)*Otz^3 + coef9(3)*Otz^2 + coef9(4)*Otz^1;
toruseqly = toruseqly + coef10(1)*pxlt^4 + coef10(2)*pxlt^3 + coef10(3)*pxlt^2 + coef10(4)*pxlt^1;
toruseqly = toruseqly + coef11(1)*pylt^4 + coef11(2)*pylt^3 + coef11(3)*pylt^2 + coef11(4)*pylt^1;
toruseqly = toruseqly + coef12(1)*pzlt^4 + coef12(2)*pzlt^3 + coef12(3)*pzlt^2 + coef12(4)*pzlt^1;
toruseqly = toruseqly + coef13(1)*Thtt^4 + coef13(2)*Thtt^3 + coef13(3)*Thtt^2 + coef13(4)*Thtt^1;
toruseqly = toruseqly + coef14(1)*Thnt^4 + coef14(2)*Thnt^3 + coef14(3)*Thnt^2 + coef14(4)*Thnt^1;

```

```

(4)*Thnt^1;
disp('finished computation of toruseqly...');
fprintf(fid, '\n\ntoruseqly = Sum of: \n');
for il = 1:4
    fprintf(fid, '%20.12f', coef6(il));
    fprintf(fid, ' Rtt^%1i', il);
    fprintf(fid, '\n');
end
for il = 1:4
    fprintf(fid, '%20.12f', coef7(il));
    fprintf(fid, ' Otxt^%1i', il);
    fprintf(fid, '\n');
end
for il = 1:4
    fprintf(fid, '%20.12f', coef8(il));
    fprintf(fid, ' Otyt^%1i', il);
    fprintf(fid, '\n');
end
for il = 1:4
    fprintf(fid, '%20.12f', coef9(il));
    fprintf(fid, ' Otzt^%1i', il);
    fprintf(fid, '\n');
end
for il = 1:4
    fprintf(fid, '%20.12f', coef10(il));
    fprintf(fid, ' pxlt^%1i', il);
    fprintf(fid, '\n');
end
for il = 1:4
    fprintf(fid, '%20.12f', coef11(il));
    fprintf(fid, ' pylt^%1i', il);
    fprintf(fid, '\n');
end
for il = 1:4
    fprintf(fid, '%20.12f', coef12(il));
    fprintf(fid, ' pzlt^%1i', il);
    fprintf(fid, '\n');
end
for il = 1:4
    fprintf(fid, '%20.12f', coef13(il));
    fprintf(fid, ' Thtt^%1i', il);
    fprintf(fid, '\n');
end
for il = 1:4
    fprintf(fid, '%20.12f', coef14(il));
    fprintf(fid, ' Thnt^%1i', il);
    fprintf(fid, '\n');
end

fprintf(fid, '\n\nTest of torusly');
Rtt = 5.0;
Otxt = 0.0;
Otyt = 0.0;
Otzt = 0.0;
pxlt = 0.0;
pylt = 0.0;
pzlt = 0.0;
Thtt = 0.0;
Thnt = 0.0;
fprintf(fid, '\nRtt = %20.12f', Rtt);
fprintf(fid, '\nOtx = %20.12f', Otxt);
fprintf(fid, '\nOty = %20.12f', Otyt);
fprintf(fid, '\nOtz = %20.12f', Otzt);
fprintf(fid, '\npxlt = %20.12f', pxlt);
fprintf(fid, '\npylt = %20.12f', pylt);
fprintf(fid, '\npzlt = %20.12f', pzlt);

```

```

fprintf(fid, '\nThtt = %20.12f', Thtt);
fprintf(fid, '\nThtnt = %20.12f', Thtnt);
fprintf(fid, '\ntorusly = %20.12f', eval(torusly));
fprintf(fid, '\n');
fprintf(fid, '\n\nTest of torusly');
Rtt = 5.0;
Otxt = 0.0;
Otyt = 0.0;
Otzt = 0.0;
pxlt = 10.0;
pylt = 0.0;
pzlt = 0.0;
Thtt = 0.0;
Thtnt = 0.0;
fprintf(fid, '\nRtt = %20.12f', Rtt);
fprintf(fid, '\nOtx = %20.12f', Otxt);
fprintf(fid, '\nOty = %20.12f', Otyt);
fprintf(fid, '\nOtz = %20.12f', Otzt);
fprintf(fid, '\npxlt = %20.12f', pxlt);
fprintf(fid, '\npylt = %20.12f', pylt);
fprintf(fid, '\npzlt = %20.12f', pzlt);
fprintf(fid, '\nThtt = %20.12f', Thtt);
fprintf(fid, '\nThtnt = %20.12f', Thtnt);
fprintf(fid, '\ntorusly = %20.12f', eval(torusly));
fprintf(fid, '\n');
fprintf(fid, '\n\nTest of torusly');
Rtt = 5.0;
Otxt = 0.0;
Otyt = 0.0;
Otzt = 0.0;
pxlt = 0.0;
pylt = 0.0;
pzlt = 10.0;
Thtt = 0.0;
Thtnt = 0.0;
fprintf(fid, '\nRtt = %20.12f', Rtt);
fprintf(fid, '\nOtx = %20.12f', Otxt);
fprintf(fid, '\nOty = %20.12f', Otyt);
fprintf(fid, '\nOtz = %20.12f', Otzt);
fprintf(fid, '\npxlt = %20.12f', pxlt);
fprintf(fid, '\npylt = %20.12f', pylt);
fprintf(fid, '\npzlt = %20.12f', pzlt);
fprintf(fid, '\nThtt = %20.12f', Thtt);
fprintf(fid, '\nThtnt = %20.12f', Thtnt);
fprintf(fid, '\ntorusly = %20.12f', eval(torusly));
fprintf(fid, '\n');
fprintf(fid, '\n\nTest of torusly');
Rtt = 5.0;
Otxt = 0.0;
Otyt = 0.0;
Otzt = 0.0;
pxlt = -10.0;
pylt = 0.0;
pzlt = 0.0;
Thtt = 0.0;
Thtnt = 0.0;
fprintf(fid, '\nRtt = %20.12f', Rtt);
fprintf(fid, '\nOtx = %20.12f', Otxt);
fprintf(fid, '\nOty = %20.12f', Otyt);
fprintf(fid, '\nOtz = %20.12f', Otzt);
fprintf(fid, '\npxlt = %20.12f', pxlt);
fprintf(fid, '\npylt = %20.12f', pylt);
fprintf(fid, '\npzlt = %20.12f', pzlt);
fprintf(fid, '\nThtt = %20.12f', Thtt);
fprintf(fid, '\nThtnt = %20.12f', Thtnt);
fprintf(fid, '\ntorusly = %20.12f', eval(torusly));

```

```

fprintf(fid,'\n');
fprintf(fid,'\n\nTest of torusly');
Rtt = 5.0;
Otxt = 0.0;
Otyt = 0.0;
Otz = 0.0;
pxlt = 0.0;
pylt = 0.0;
pzlt = -10.0;
Thtt = 0.0;
Thnt = 0.0;
fprintf(fid,'\nRtt = %20.12f',Rtt);
fprintf(fid,'\nOtx = %20.12f',Otxt);
fprintf(fid,'\nOty = %20.12f',Otyt);
fprintf(fid,'\nOtz = %20.12f',Otz);
fprintf(fid,'\npxlt = %20.12f',pxlt);
fprintf(fid,'\npylt = %20.12f',pylt);
fprintf(fid,'\npzlt = %20.12f',pzlt);
fprintf(fid,'\nThtt = %20.12f',Thtt);
fprintf(fid,'\nThnt = %20.12f',Thnt);
fprintf(fid,'\ntorusly = %20.12f',eval(torusly));
fprintf(fid,'\n');

syms coef6 coef7 coef8 coef9 coef10 coef11 coef12 coef13 coef14;

r1 = 1.0;
Otx = 0;
Oty = 0;
Otz = 0;
xpt = Otx + Rt*cos(Tht);
ypt = Oty + Rt*sin(Tht);
rpt = sqrt((xpt - Otx)^2 + (ypt - Oty)^2);
xt = xpt;
yt = ypt;
%; thpt = itan1(xt,yt);
syms thpt;
thcum = thpt + Thtn;
x0 = rpt*cos(thcum);
y0 = rpt*sin(thcum);
th1 = Tht;
th2 = 0;
nr = 8;
thp = 2*3.14159/nr;
Tht = thp*i1;
Rt = 20;
toruslz = 0;
for i1 = 1:nr
    thpt = itan1(xt,yt);
    toruslz = toruslz + circlelz;
end
a1 = [Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [eval(toruslz);];
Rt = 60;
toruslz = 0;
for i1 = 1:nr
    thpt = itan1(xt,yt);
    toruslz = toruslz + circlelz;
end
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [b1; eval(toruslz);];
Rt = 240;
toruslz = 0;
for i1 = 1:nr
    thpt = itan1(xt,yt);
    toruslz = toruslz + circlelz;
end

```



```

a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^2;];
b1 = [b1; eval(toruslz);];
Rt = 2400;
toruslz = 0;
for il = 1:nr
    thpt = itan1(xt,yt);
    toruslz = toruslz + circlelz;
end
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^2;];
b1 = [b1; eval(toruslz);];
%;
%; The following is the first set of coefficients of the torus equation for Rt = variable
%;
coef6 = pinv(a1)*b1;
disp('coef6...');
x0 = Otx + Rt*cos(Tht);
y0 = Oty + Rt*sin(Tht);
th1 = Tht;
nr = 8;
thp = 2*3.14159/nr;
Tht = thp*il;
Rt = 20;
Otx = 8*r1;
toruslz = 0;
for il = 1:nr
    toruslz = toruslz + circlelz;
end
a1 = [Otx^4 Otx^3 Otx^2 Otx^1;];
b1 = [(eval(toruslz) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1);];
Otx = 64*r1;
toruslz = 0;
for il = 1:nr
    toruslz = toruslz + circlelz;
end
a1 = [a1; Otx^4 Otx^3 Otx^2 Otx^1;];
b1 = [b1; (eval(toruslz) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1);];
Otx = -8*r1;
toruslz = 0;
for il = 1:nr
    toruslz = toruslz + circlelz;
end
a1 = [a1; Otx^4 Otx^3 Otx^2 Otx^1;];
b1 = [b1; (eval(toruslz) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1);];
Otx = -64*r1;
toruslz = 0;
for il = 1:nr
    toruslz = toruslz + circlelz;
end
a1 = [a1; Otx^4 Otx^3 Otx^2 Otx^1;];
b1 = [b1; (eval(toruslz) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1);];

%;
%; The following is the first set of coefficients of the torus equation for Rt = 20, Otx =
variable
%;
coef7 = pinv(a1)*b1;
disp('coef7...');
x0 = Otx + Rt*cos(Tht);
y0 = Oty + Rt*sin(Tht);
th1 = Tht;
nr = 8;
thp = 2*3.14159/nr;
Tht = thp*il;

```

```

Rt = 20;
Otx = 0;
Oty = 8*r1;
toruslz = 0;
for il = 1:nr
    toruslz = toruslz + circlelz;
end
a1 = [Oty^4 Oty^3 Oty^2 Oty^1;];
tmp = eval(toruslz) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
b1 = [tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;];
Oty = 64*r1;
toruslz = 0;
for il = 1:nr
    toruslz = toruslz + circlelz;
end
a1 = [a1; Oty^4 Oty^3 Oty^2 Oty^1;];
tmp = eval(toruslz) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
b1 = [b1; tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;];
Oty = -8*r1;
toruslz = 0;
for il = 1:nr
    toruslz = toruslz + circlelz;
end
a1 = [a1; Oty^4 Oty^3 Oty^2 Oty^1;];
tmp = eval(toruslz) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
b1 = [b1; tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;];
Oty = -64*r1;
toruslz = 0;
for il = 1:nr
    toruslz = toruslz + circlelz;
end
a1 = [a1; Oty^4 Oty^3 Oty^2 Oty^1;];
tmp = eval(toruslz) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
b1 = [b1; tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;];

%;
%; The following is the first set of coefficients of the torus equation for Rt = 20, Otx =
0, Oty = variable
%;
coef8 = pinv(a1)*b1;
disp('coef8...');
x0 = Otx + Rt*cos(Tht);
y0 = Oty + Rt*sin(Tht);
th1 = Tht;
nr = 8;
thp = 2*3.14159/nr;
Tht = thp*il;
Rt = 20;
Otx = 0;
Oty = 0;
Otz = 8*r1;
toruslz = 0;
for il = 1:nr
    toruslz = toruslz + circlelz;
end
a1 = [Otz^4 Otz^3 Otz^2 Otz^1;];
tmp = eval(toruslz) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
tmp = tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;
b1 = [tmp - coef8(1)*Oty^4 - coef8(2)*Oty^3 - coef8(3)*Oty^2 - coef8(4)*Oty^1;];
Otz = 64*r1;
toruslz = 0;
for il = 1:nr
    toruslz = toruslz + circlelz;
end
a1 = [a1; Otz^4 Otz^3 Otz^2 Otz^1;];
tmp = eval(toruslz) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;

```

```

tmp = tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;
b1 = [b1; tmp - coef8(1)*Oty^4 - coef8(2)*Oty^3 - coef8(3)*Oty^2 - coef8(4)*Oty^1;];
Otz = -8*r1;
torus1z = 0;
for il = 1:nr
    torus1z = torus1z + circle1z;
end
a1 = [a1; Otz^4 Otz^3 Otz^2 Otz^1;];
tmp = eval(torus1z) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
tmp = tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;
b1 = [b1; tmp - coef8(1)*Oty^4 - coef8(2)*Oty^3 - coef8(3)*Oty^2 - coef8(4)*Oty^1;];
Otz = -64*r1;
torus1z = 0;
for il = 1:nr
    torus1z = torus1z + circle1z;
end
a1 = [a1; Otz^4 Otz^3 Otz^2 Otz^1;];
tmp = eval(torus1z) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
tmp = tmp - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;
b1 = [b1; tmp - coef8(1)*Oty^4 - coef8(2)*Oty^3 - coef8(3)*Oty^2 - coef8(4)*Oty^1;];

%;
% The following is the first set of coefficients of the torus equation for Rt = 20, Otx =
0, Oty = 0, Otz = var.
%;
coef9 = pinv(a1)*b1;
disp('coef9...');
%;
x0 = Otx + Rt*cos(Tht);
y0 = Oty + Rt*sin(Tht);
th1 = Tht;
nr = 8;
thp = 2*3.14159/nr;
ht = thp*il;
Rt = k1*r1;
Otx = k2*r1;
Oty = k3*r1;
Otz = k4*r1;
px1 = 2*r1;
torus1z = 0;
for il = 1:nr
    torus1z = torus1z + circle1z;
end
a1 = [px1^4 px1^3 px1^2 px1^1;];
tmp1 = eval(torus1z) - coef6(1)*Rt^4 - coef6(2)*Rt^3 - coef6(3)*Rt^2 - coef6(4)*Rt^1;
tmp1 = tmp1 - coef7(1)*Otx^4 - coef7(2)*Otx^3 - coef7(3)*Otx^2 - coef7(4)*Otx^1;
tmp1 = tmp1 - coef8(1)*Oty^4 - coef8(2)*Oty^3 - coef8(3)*Oty^2 - coef8(4)*Oty^1;
tmp1 = tmp1 - coef9(1)*Otz^4 - coef9(2)*Otz^3 - coef9(3)*Otz^2 - coef9(4)*Otz^1;

b1 = [tmp1;];
px1 = 8*r1;
torus1z = 0;
for il = 1:nr
    torus1z = torus1z + circle1z;
end
a1 = [a1; px1^4 px1^3 px1^2 px1^1;];
b1 = [b1; tmp1;];
px1 = 32*r1;
torus1z = 0;
for il = 1:nr
    torus1z = torus1z + circle1z;
end
a1 = [a1; px1^4 px1^3 px1^2 px1^1;];
b1 = [b1; tmp1;];
px1 = 200*r1;
torus1z = 0;

```

```

for il = 1:nr
    toruslz = toruslz + circlelz;
end
a1 = [a1; px1^4 px1^3 px1^2 px1^1;];
b1 = [b1; tmp1;];
%;
%; coefficients of the torus equation for (...) px1 = variable
%;
coef10 = pinv(a1)*b1;
disp('coef10...');

px1 = 2*r1;
py1 = 2*r1;
toruslz = 0;
for il = 1:nr
    toruslz = toruslz + circlelz;
end
a1 = [py1^4 py1^3 py1^2 py1^1;];
b1 = [tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;];
py1 = 8*r1;
toruslz = 0;
for il = 1:nr
    toruslz = toruslz + circlelz;
end
a1 = [a1; py1^4 py1^3 py1^2 py1^1;];
b1 = [b1; tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;];
py1 = 32*r1;
toruslz = 0;
for il = 1:nr
    toruslz = toruslz + circlelz;
end
a1 = [a1; py1^4 py1^3 py1^2 py1^1;];
b1 = [b1; tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;];
py1 = 200*r1;
toruslz = 0;
for il = 1:nr
    toruslz = toruslz + circlelz;
end
a1 = [a1; py1^4 py1^3 py1^2 py1^1;];
b1 = [b1; tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;];
%;
%; coefficients of the torus equation for (...) py1 = variable
%;
coef11 = pinv(a1)*b1;
disp('coef11...');
px1 = 2*r1;
py1 = 2*r1;
pz1 = 2*r1;
toruslz = 0;
for il = 1:nr
    toruslz = toruslz + circlelz;
end
a1 = [pz1^4 pz1^3 pz1^2 pz1^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
b1 = [tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;];
pz1 = 8*r1;
toruslz = 0;
for il = 1:nr
    toruslz = toruslz + circlelz;
end
a1 = [a1; pz1^4 pz1^3 pz1^2 pz1^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
b1 = [b1; tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;];
pz1 = 32*r1;
toruslz = 0;
for il = 1:nr

```

```

    toruslz = toruslz + circlelz;
end
a1 = [a1; pz1^4 pz1^3 pz1^2 pz1^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
b1 = [b1; tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;];
pz1 = 200*r1;
toruslz = 0;
for il = 1:nr
    toruslz = toruslz + circlelz;
end
a1 = [a1; pz1^4 pz1^3 pz1^2 pz1^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
b1 = [b1; tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;];

%;
%; coefficients of the torus equation for (...) pz1 = variable
%;
coef12 = pinv(a1)*b1;
disp('coef12...');
px1 = 2*r1;
py1 = 2*r1;
pz1 = 2*r1;
Tht = 3.14159/2;
toruslz = 0;
for il = 1:nr
    toruslz = toruslz + circlelz;
end
a1 = [Tht^4 Tht^3 Tht^2 Tht^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
b1 = [tmp - coef12(1)*pz1^4 - coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;];
Tht = 3.14159;
toruslz = 0;
for il = 1:nr
    toruslz = toruslz + circlelz;
end
a1 = [a1; Tht^4 Tht^3 Tht^2 Tht^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
b1 = [b1; tmp - coef12(1)*pz1^4 - coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;];
Tht = 3*3.14159/2;
toruslz = 0;
for il = 1:nr
    toruslz = toruslz + circlelz;
end
a1 = [a1; Tht^4 Tht^3 Tht^2 Tht^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
b1 = [b1; tmp - coef12(1)*pz1^4 - coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;];
Tht = 2*3.14159;
toruslz = 0;
for il = 1:nr
    toruslz = toruslz + circlelz;
end
a1 = [a1; Tht^4 Tht^3 Tht^2 Tht^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
b1 = [b1; tmp - coef12(1)*pz1^4 - coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;];

%;
%; coefficients of the torus equation for (...) Tht = variable
%;
coef13 = pinv(a1)*b1;
disp('coef13...');
px1 = 2*r1;
py1 = 2*r1;

```

```

pz1 = 2*r1;
Tht = 0.0;
Thtn = 3.14159/2;
toruslz = 0;
for il = 1:nr
    toruslz = toruslz + circlelz;
end
a1 = [Thtn^4 Thtn^3 Thtn^2 Thtn^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
tmp = tmp - coef12(1)*pz1^4 - coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;
b1 = [tmp - coef13(1)*Tht^4 - coef13(2)*Tht^3 - coef13(3)*Tht^2 - coef13(4)*Tht^1;];
Thtn = 3.14159;
toruslz = 0;
for il = 1:nr
    toruslz = toruslz + circlelz;
end
a1 = [a1; Thtn^4 Thtn^3 Thtn^2 Thtn^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
tmp = tmp - coef12(1)*pz1^4 - coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;
b1 = [b1; tmp - coef13(1)*Tht^4 - coef13(2)*Tht^3 - coef13(3)*Tht^2 - coef13(4)*Tht^1;];
Thtn = 3*3.14159/2;
toruslz = 0;
for il = 1:nr
    toruslz = toruslz + circlelz;
end
a1 = [a1; Thtn^4 Thtn^3 Thtn^2 Thtn^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
tmp = tmp - coef12(1)*pz1^4 - coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;
b1 = [b1; tmp - coef13(1)*Tht^4 - coef13(2)*Tht^3 - coef13(3)*Tht^2 - coef13(4)*Tht^1;];
Thtn = 2*3.14159;
toruslz = 0;
for il = 1:nr
    toruslz = toruslz + circlelz;
end
a1 = [a1; Thtn^4 Thtn^3 Thtn^2 Thtn^1;];
tmp = tmp1 - coef10(1)*px1^4 - coef10(2)*px1^3 - coef10(3)*px1^2 - coef10(4)*px1^1;
tmp = tmp - coef11(1)*py1^4 - coef11(2)*py1^3 - coef11(3)*py1^2 - coef11(4)*py1^1;
tmp = tmp - coef12(1)*pz1^4 - coef12(2)*pz1^3 - coef12(3)*pz1^2 - coef12(4)*pz1^1;
b1 = [b1; tmp - coef13(1)*Tht^4 - coef13(2)*Tht^3 - coef13(3)*Tht^2 - coef13(4)*Tht^1;];

%;
%; coefficients of the torus equation for (...) Thtn = variable
%;
coef14 = pinv(a1)*b1;
disp('coef14...');

%;
%; Now, finally the complete torus equation
%;

%;coef6 = eval(coef6);
%;coef7 = eval(coef7);
%;coef8 = eval(coef8);
%;coef9 = eval(coef9);
%;coef10 = eval(coef10);
%;coef11 = eval(coef11);
%;coef12 = eval(coef12);
%;coef13 = eval(coef13);
%;coef14 = eval(coef14);

syms Rtt Ottx Otty Otzt pxlt pylt pzlt Thtt Thnt;

toruseqlz = coef6(1)*Rtt^4 + coef6(2)*Rtt^3 + coef6(3)*Rtt^2 + coef6(4)*Rtt^1;

```

```

toruseqlz = toruseqlz + coef7(1)*Otzt^4 + coef7(2)*Otzt^3 + coef7(3)*Otzt^2 + coef7(4)
*Otzt^1;
toruseqlz = toruseqlz + coef8(1)*Otyt^4 + coef8(2)*Otyt^3 + coef8(3)*Otyt^2 + coef8(4)
*Otyt^1;
oruseqlz = toruseqlz + coef9(1)*Otzt^4 + coef9(2)*Otzt^3 + coef9(3)*Otzt^2 + coef9(4)
Otzt^1;
toruseqlz = toruseqlz + coef10(1)*pxlt^4 + coef10(2)*pxlt^3 + coef10(3)*pxlt^2 + coef10(4)
*pxlt^1;
toruseqlz = toruseqlz + coef11(1)*pylt^4 + coef11(2)*pylt^3 + coef11(3)*pylt^2 + coef11(4)
*pylt^1;
toruseqlz = toruseqlz + coef12(1)*pzlt^4 + coef12(2)*pzlt^3 + coef12(3)*pzlt^2 + coef12(4)
*pzlt^1;
toruseqlz = toruseqlz + coef13(1)*Thtt^4 + coef13(2)*Thtt^3 + coef13(3)*Thtt^2 + coef13(4)
*Thtt^1;
toruseqlz = toruseqlz + coef14(1)*Thtnt^4 + coef14(2)*Thtnt^3 + coef14(3)*Thtnt^2 + coef14
(4)*Thtnt^1;
disp('finished computation of toruseqlz...');
fprintf(fid,'\n\ntoruseqlz = Sum of: \n');
for il = 1:4
    fprintf(fid,'%20.12f',coef6(il));
    fprintf(fid,' Rtt^%li',il);
    fprintf(fid,'\n');
end
for il = 1:4
    fprintf(fid,'%20.12f',coef7(il));
    fprintf(fid,' Otzt^%li',il);
    fprintf(fid,'\n');
end
for il = 1:4
    fprintf(fid,'%20.12f',coef8(il));
    fprintf(fid,' Otyt^%li',il);
    fprintf(fid,'\n');
end
for il = 1:4
    fprintf(fid,'%20.12f',coef9(il));
    fprintf(fid,' Otzt^%li',il);
    fprintf(fid,'\n');
end
for il = 1:4
    fprintf(fid,'%20.12f',coef10(il));
    fprintf(fid,' pxlt^%li',il);
    fprintf(fid,'\n');
end
for il = 1:4
    fprintf(fid,'%20.12f',coef11(il));
    fprintf(fid,' pylt^%li',il);
    fprintf(fid,'\n');
end
for il = 1:4
    fprintf(fid,'%20.12f',coef12(il));
    fprintf(fid,' pzlt^%li',il);
    fprintf(fid,'\n');
end
for il = 1:4
    fprintf(fid,'%20.12f',coef13(il));
    fprintf(fid,' Thtt^%li',il);
    fprintf(fid,'\n');
end
for il = 1:4
    fprintf(fid,'%20.12f',coef14(il));
    fprintf(fid,' Thtnt^%li',il);
    fprintf(fid,'\n');
end

fprintf(fid,'\n\nTest of toruslz');
Rtt = 5.0;

```

```

Otxt = 0.0;
Otyt = 0.0;
Otzt = 0.0;
pxlt = 0.0;
pylt = 0.0;
pzlt = 0.0;
Thtt = 0.0;
Thtnt = 0.0;
fprintf(fid, '\nRtt = %20.12f', Rtt);
fprintf(fid, '\nOtx = %20.12f', Otxt);
fprintf(fid, '\nOty = %20.12f', Otyt);
fprintf(fid, '\nOtz = %20.12f', Otzt);
fprintf(fid, '\npxlt = %20.12f', pxlt);
fprintf(fid, '\npylt = %20.12f', pylt);
fprintf(fid, '\npzlt = %20.12f', pzlt);
fprintf(fid, '\nThtt = %20.12f', Thtt);
fprintf(fid, '\nThtnt = %20.12f', Thtnt);
fprintf(fid, '\ntoruslz = %20.12f', eval(toruslz));
fprintf(fid, '\n');
fprintf(fid, '\n\nTest of toruslz');
Rtt = 5.0;
Otxt = 0.0;
Otyt = 0.0;
Otzt = 0.0;
pxlt = 10.0;
pylt = 0.0;
pzlt = 0.0;
Thtt = 0.0;
Thtnt = 0.0;
fprintf(fid, '\nRtt = %20.12f', Rtt);
fprintf(fid, '\nOtx = %20.12f', Otxt);
fprintf(fid, '\nOty = %20.12f', Otyt);
fprintf(fid, '\nOtz = %20.12f', Otzt);
fprintf(fid, '\npxlt = %20.12f', pxlt);
fprintf(fid, '\npylt = %20.12f', pylt);
fprintf(fid, '\npzlt = %20.12f', pzlt);
fprintf(fid, '\nThtt = %20.12f', Thtt);
fprintf(fid, '\nThtnt = %20.12f', Thtnt);
fprintf(fid, '\ntoruslz = %20.12f', eval(toruslz));
fprintf(fid, '\n');
fprintf(fid, '\n\nTest of toruslz');
Rtt = 5.0;
Otxt = 0.0;
Otyt = 0.0;
Otzt = 0.0;
pxlt = 0.0;
pylt = 0.0;
pzlt = 10.0;
Thtt = 0.0;
Thtnt = 0.0;
fprintf(fid, '\nRtt = %20.12f', Rtt);
fprintf(fid, '\nOtx = %20.12f', Otxt);
fprintf(fid, '\nOty = %20.12f', Otyt);
fprintf(fid, '\nOtz = %20.12f', Otzt);
fprintf(fid, '\npxlt = %20.12f', pxlt);
fprintf(fid, '\npylt = %20.12f', pylt);
fprintf(fid, '\npzlt = %20.12f', pzlt);
fprintf(fid, '\nThtt = %20.12f', Thtt);
fprintf(fid, '\nThtnt = %20.12f', Thtnt);
fprintf(fid, '\ntoruslz = %20.12f', eval(toruslz));
fprintf(fid, '\n');
fprintf(fid, '\n\nTest of toruslz');
Rtt = 5.0;
Otxt = 0.0;
Otyt = 0.0;
Otzt = 0.0;

```



```

pxlt = -10.0;
pylt = 0.0;
pzlt = 0.0;
Thtt = 0.0;
Thmnt = 0.0;
fprintf(fid, '\nRtt = %20.12f', Rtt);
fprintf(fid, '\nOtx = %20.12f', Otx);
fprintf(fid, '\nOty = %20.12f', Oty);
fprintf(fid, '\nOtz = %20.12f', Otzt);
fprintf(fid, '\npxlt = %20.12f', pxlt);
fprintf(fid, '\npylt = %20.12f', pylt);
fprintf(fid, '\npzlt = %20.12f', pzlt);
fprintf(fid, '\nThtt = %20.12f', Thtt);
fprintf(fid, '\nThmnt = %20.12f', Thmnt);
fprintf(fid, '\ntoruslz = %20.12f', eval(toruslz));
fprintf(fid, '\n');
fprintf(fid, '\n\nTest of toruslz');
Rtt = 5.0;
Otx = 0.0;
Oty = 0.0;
Otzt = 0.0;
pxlt = 0.0;
pylt = 0.0;
pzlt = -10.0;
Thtt = 0.0;
Thmnt = 0.0;
fprintf(fid, '\nRtt = %20.12f', Rtt);
fprintf(fid, '\nOtx = %20.12f', Otx);
fprintf(fid, '\nOty = %20.12f', Oty);
fprintf(fid, '\nOtz = %20.12f', Otzt);
fprintf(fid, '\npxlt = %20.12f', pxlt);
fprintf(fid, '\npylt = %20.12f', pylt);
fprintf(fid, '\npzlt = %20.12f', pzlt);
fprintf(fid, '\nThtt = %20.12f', Thtt);
fprintf(fid, '\nThmnt = %20.12f', Thmnt);
fprintf(fid, '\ntoruslz = %20.12f', eval(toruslz));
fprintf(fid, '\n');

%;
%; compute the multi-torus equation
%; - ...f(x,y,z,r1,r2,th1,th2,r3,thml)
%; - cumulative equation generated with a for loop
%;

pxlt = px1;
pylt = py1;
pzlt = pz1;
thlt = th1;
th2t = th2;

syms Rmt Thmt nT tmpmTx tmpmTy tmpmTz coef15 coef16;
Otx = Rmt*cos(Thmt);
Oty = Rmt*sin(Thmt);
Otzt = 0.0;
Thtt = 0.0;
Thmnt = 0.0;
nT = 16;
Rtt = 20*r1;

tmpmTx = 0;
for il = 1:nT
    Thmt = il*2*3.14159/nT;
    tmpmTx = tmpmTx + toruseqlx;
end

```

```

Rmt = 1000*r1;
a1 = [Rmt^4 Rmt^3 Rmt^2 Rmt^1;];
b1 = [eval(tmpmTx);];
Rmt = 2000*r1;
a1 = [a1; Rmt^4 Rmt^3 Rmt^2 Rmt^1;];
b1 = [b1; eval(tmpmTx);];
Rmt = 10000*r1;
a1 = [a1; Rmt^4 Rmt^3 Rmt^2 Rmt^1;];
b1 = [b1; eval(tmpmTx);];
Rmt = 160000*r1;
a1 = [a1; Rmt^4 Rmt^3 Rmt^2 Rmt^1;];
b1 = [b1; eval(tmpmTx);];
%;
%; These are the coeff. for the multi-torus eq. Rmt = variable
%;
coef15 = pinv(a1)*b1;
disp('coef15...');

Rmt = 1200*r1;
Rt = 20*r1;
a1 = [Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [eval(tmpmTx) - coef15(1)*Rmt^4 - coef15(2)*Rmt^3 - coef15(3)*Rmt^2 coef15(4)*Rmt^1;];
Rt = 40*r1;
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [b1; eval(tmpmTx) - coef15(1)*Rmt^4 - coef15(2)*Rmt^3 - coef15(3)*Rmt^2 coef15(4)*Rmt^1;];
Rt = 80*r1;
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [b1; eval(tmpmTx) - coef15(1)*Rmt^4 - coef15(2)*Rmt^3 - coef15(3)*Rmt^2 coef15(4)*Rmt^1;];
Rt = 120*r1;
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [b1; eval(tmpmTx) - coef15(1)*Rmt^4 - coef15(2)*Rmt^3 - coef15(3)*Rmt^2 coef15(4)*Rmt^1;];
%;
%; These are the coeff. for the multi-torus eq. Rmt = 1200, Rt = variable
%;
coef16 = pinv(a1)*b1;
disp('coef16...');

%;
%; Here is the final multi-torus equation (fox x here)
%;
syms multitorus1x multitorusly multitoruslz;
coef15 = eval(coef15);
coef16 = eval(coef16);
multitorus1x = coef15(1)*Rmt^4 + coef15(2)*Rmt^3 + coef15(3)*Rmt^2 + coef15(4)*Rmt^1;
multitorus1x = multitorus1x + coef16(1)*Rt^4 + coef16(2)*Rt^3 + coef16(3)*Rt^2 + coef16(4)*Rt^1;
disp('finished computation of multitorus1x...');
fprintf(fid, '\n\nmultitorus1x = Sum of: \n');
for il = 1:4
    fprintf(fid, '%20.12f', coef15(il));
    fprintf(fid, ' Rmt^%li', il);
    fprintf(fid, '\n');
end
for il = 1:4
    fprintf(fid, '%20.12f', coef16(il));
    fprintf(fid, ' Rt^%li', il);
    fprintf(fid, '\n');
end
fprintf(fid, '\n\nTest of multitorus1x');
Rt = 20;
Rmt = 100;

```

```

fprintf(fid, '\nRt = %20.12f', Rt);
fprintf(fid, '\nRmt = %20.12f', Rmt);
fprintf(fid, '\nmultitoruslx = %20.12f', multitoruslx);
fprintf(fid, '\n');

```

```

Otxt = Rmt*cos(Thmt);
Otyt = Rmt*sin(Thmt);
Otz = 0.0;
Thmt = 0.0;
nT = 16;

```

```

tmpmTy = 0;
for i1 = 1:nT
    Thmt = i1*2*3.14159/nT;
    tmpmTy = tmpmTy + toruseqly;
end

```

```

Rmt = 1000*r1;
a1 = [Rmt^4 Rmt^3 Rmt^2 Rmt^1;];
b1 = [eval(tmpmTy);];
Rmt = 2000*r1;
a1 = [a1; Rmt^4 Rmt^3 Rmt^2 Rmt^1;];
b1 = [b1; eval(tmpmTy);];
Rmt = 10000*r1;
a1 = [a1; Rmt^4 Rmt^3 Rmt^2 Rmt^1;];
b1 = [b1; eval(tmpmTy);];
Rmt = 160000*r1;
a1 = [a1; Rmt^4 Rmt^3 Rmt^2 Rmt^1;];
b1 = [b1; eval(tmpmTy);];

```

```

%;
%; These are the coeff. for the multi-torus eq. Rmt = variable
%;
coef15 = pinv(a1)*b1;
disp('coef15...');

```

```

Rmt = 1200*r1;
Rt = 20*r1;
a1 = [Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [eval(tmpmTy) - coef15(1)*Rmt^4 - coef15(2)*Rmt^3 - coef15(3)*Rmt^2 coef15(4)*Rmt^1;];
Rt = 40*r1;
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [b1; eval(tmpmTy) - coef15(1)*Rmt^4 - coef15(2)*Rmt^3 - coef15(3)*Rmt^2 coef15(4)*Rmt^1;];
Rt = 80*r1;
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [b1; eval(tmpmTy) - coef15(1)*Rmt^4 - coef15(2)*Rmt^3 - coef15(3)*Rmt^2 coef15(4)*Rmt^1;];
Rt = 120*r1;
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [b1; eval(tmpmTy) - coef15(1)*Rmt^4 - coef15(2)*Rmt^3 - coef15(3)*Rmt^2 coef15(4)*Rmt^1;];

```

```

%;
%; These are the coeff. for the multi-torus eq. Rmt = 1200, Rt = variable
%;
coef16 = pinv(a1)*b1;
disp('coef16...');

```

```

%;
%; Here is the final multi-torus equation
%;
syms Rt Rmt;
multitorusly = coef15(1)*Rmt^4 + coef15(2)*Rmt^3 + coef15(3)*Rmt^2 + coef15(4)*Rmt^1;

```

```

multitorusly = multitorusly + coef16(1)*Rt^4 + coef16(2)*Rt^3 + coef16(3)*Rt^2 + coef16(4)
*Rt^1;
disp('finished computation of multitorusly...');
fprintf(fid, '\n\nmultitorusly = Sum of: \n');
    or il = 1:4
        fprintf(fid, '%20.12f', coef15(il));
        fprintf(fid, ' Rmt^%li', il);
        fprintf(fid, '\n');
    end
    for il = 1:4
        fprintf(fid, '%20.12f', coef16(il));
        fprintf(fid, ' Rt^%li', il);
        fprintf(fid, '\n');
    end
fprintf(fid, '\n\nTest of multitorusly');
Rt = 20;
Rmt = 100;
fprintf(fid, '\nRt = %20.12f', Rt);
fprintf(fid, '\nRmt = %20.12f', Rmt);
fprintf(fid, '\nmultitorusly = %20.12f', eval(multitorusly));
fprintf(fid, '\n');

Otx = Rmt*cos(Thmt);
Oty = Rmt*sin(Thmt);
Otz = 0.0;
nT = 16;

tmpmTz = 0;
for il = 1:nT
    Thmt = il*2*3.14159/nT;
    tmpmTz = tmpmTz + toruseqlz;
end

Rmt = 1000*r1;
a1 = [Rmt^4 Rmt^3 Rmt^2 Rmt^1;];
b1 = [eval(tmpmTz);];
Rmt = 2000*r1;
a1 = [a1; Rmt^4 Rmt^3 Rmt^2 Rmt^1;];
b1 = [b1; eval(tmpmTz);];
Rmt = 10000*r1;
a1 = [a1; Rmt^4 Rmt^3 Rmt^2 Rmt^1;];
b1 = [b1; eval(tmpmTz);];
Rmt = 160000*r1;
a1 = [a1; Rmt^4 Rmt^3 Rmt^2 Rmt^1;];
b1 = [b1; eval(tmpmTz);];

%;
%; These are the coeff. for the multi-torus eq. Rmt = variable
%;
coef15 = pinv(a1)*b1;
disp('coef15...');

Rmt = 1200*r1;
Rt = 20*r1;
a1 = [Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [eval(tmpmTz) - coef15(1)*Rmt^4 - coef15(2)*Rmt^3 - coef15(3)*Rmt^2 coef15(4)*Rmt^1;];
Rt = 40*r1;
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [b1; eval(tmpmTz) - coef15(1)*Rmt^4 - coef15(2)*Rmt^3 - coef15(3)*Rmt^2 coef15(4)*Rmt^1;];
Rt = 80*r1;
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [b1; eval(tmpmTz) - coef15(1)*Rmt^4 - coef15(2)*Rmt^3 - coef15(3)*Rmt^2 coef15(4)*Rmt^1;];

```

```

Rt = 120*r1;
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [b1; eval(tmpmTz) - coef15(1)*Rmt^4 - coef15(2)*Rmt^3 - coef15(3)*Rmt^2 coef15(4)
*Rmt^1;];
%;
%; These are the coeff. for the multi-torus eq. Rmt = 1200, Rt = variable
%;
coef16 = pinv(a1)*b1;
disp('coef16...');

%;
%; Here is the final multi-torus equation
%;

multitorus1z = coef15(1)*Rmt^4 + coef15(2)*Rmt^3 + coef15(3)*Rmt^2 + coef15(4)*Rmt^1;
multitorus1z = multitorus1z + coef16(1)*Rt^4 + coef16(2)*Rt^3 + coef16(3)*Rt^2 + coef16(4)
*Rt^1;
disp('finished computation of multitorus1z...');
fprintf(fid,'\n\nmultitorus1z = Sum of: \n');
for i1 = 1:4
    fprintf(fid,'%20.12f',coef15(i1));
    fprintf(fid,' Rt^%1i',i1);
    fprintf(fid,'\n');
end
for i1 = 1:4
    fprintf(fid,'%20.12f',coef16(i1));
    fprintf(fid,' Rt^%1i',i1);
    fprintf(fid,'\n');
end
fprintf(fid,'\n\nTest of multitorus1z');
Rt = 20;
Rmt = 100;
fprintf(fid,'\nRt = %20.12f',Rt);
fprintf(fid,'\nRmt = %20.12f',Rmt);
fprintf(fid,'\nmultitorus1z = %20.12f',multitorus1z);
fprintf(fid,'\n');

%;
%; compute the plasma-torus equation
%; - plasma toroid equation is f(pr1,pth1,pth2,pr2)
%; - inner ring x = r*cos(pth1) y = r*sin(pth1)
%; - outer branch is 1st toroid equation
%; - vector inward is from outer branch point directed back to ring
%; - final toroid equation is projection of Bx,By,Bz onto vector in
%; - cos thbp = Bx*vix + circlely*viz + circlelz*viz/ || B || || vi ||
%; - proj. = || B || cos thbp
%; - ...the multi-torus crossed with the plasma-torus
syms plrad plrad2 pth1 plx1 ply1 plz1 proj1 proj2 proj3 proj4 ptplx1 ptply1 ptplz1;
syms vec1x vec1y vec1z;
Otxt = Otx;
Otyt = Oty;
Otzt = Otz;
Thtt = Tht;
Thtnt = Thtn;

pth1 = 3.14159/2;
plx1 = plrad*cos(pth1);
ply1 = plrad*sin(pth1);
lz1 = 0.0;
pth2 = pth1/(2*3.14159*plrad);
proj1 = plrad2*cos(pth2);
proj2 = (plrad + proj1)*cos(pth1);
proj3 = plrad2*sin(pth2);

```

```

proj4 = proj1*sin(pth1);
ptplx1 = proj2;
ptply1 = proj4;
ptplz1 = proj3;
vec1x = ptplx1 - plx1;
vec1y = ptply1 - ply1;
vec1z = ptplz1 - plz1;
plrad = Rmt;
plrad2 = Rtt;

syms disB disVec thbp projMt;

disB = sqrt(multitoruslx^2 + multitorusly^2 + multitoruslz^2);
disVec = sqrt(vec1x^2 + vec1y^2 + vec1z^2);
thbp = acos((multitoruslx*vec1x + multitorusly*vec1y + multitoruslz*vec1z)/(disB*disVec));
projMt = disB*cos(thbp);
disp('finished computation of projMt...');
fprintf(fid, '\n\ndisB = ');
fprintf(fid, '\ndisB = %20.12f', eval(disB));
fprintf(fid, '\ndisVec = ');
fprintf(fid, char(disVec));
fprintf(fid, '\nthbp = ');
fprintf(fid, char(thbp));
fprintf(fid, '\nprojMt = ');
fprintf(fid, char(projMt));
fprintf(fid, '\n');

%;
%; compute the minimum of the plasma-torus equation
%; - compute the derivative of the plasma-torus equation
%; - ...derivative is found with matlab
%; - set the minimum to the necessary pressure and temperature for
%; - ...fusion
%; - compute all of the roots of the derivative
%; - ...roots are found with matlab
%; - find the root that produces the minimum
%; - ...by going down the list
%;
%; f(Rt, Rmt, ptplx1, ptply1, ptplz1) matrix (4 terms per variable)
%; find first derivative
%; find roots of first derivative
syms coef17 coef18 coef19 coef20 coef21;
Otxt = Otx;
Otyt = Oty;
Otzt = Otz;

Rt = 20;

Rtt = Rt;

a1 = [Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [eval(projMt);];
Rt = 40;
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [b1; eval(projMt);];
Rt = 80;
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [b1; eval(projMt);];
Rt = 160;
a1 = [a1; Rt^4 Rt^3 Rt^2 Rt^1;];
b1 = [b1; eval(projMt);];
coef17 = pinv(a1)*b1;

```

```

disp('coef17...');

Rt = 20;
Rmt = 100;
a1 = [Rmt^4 Rmt^3 Rmt^2 Rmt^1;];
b1 = [eval(projMt) - coef17(1)*Rt^4 - coef17(2)*Rt^3 - coef17(3)*Rt^2 - coef17(4)*Rt^1;];
Rmt = 200;
a1 = [a1; Rmt^4 Rmt^3 Rmt^2 Rmt^1;];
b1 = [b1; eval(projMt) - coef17(1)*Rt^4 - coef17(2)*Rt^3 - coef17(3)*Rt^2 - coef17(4)*Rt^1;];
Rmt = 400;
a1 = [a1; Rmt^4 Rmt^3 Rmt^2 Rmt^1;];
b1 = [b1; eval(projMt) - coef17(1)*Rt^4 - coef17(2)*Rt^3 - coef17(3)*Rt^2 - coef17(4)*Rt^1;];
Rmt = 800;
a1 = [a1; Rmt^4 Rmt^3 Rmt^2 Rmt^1;];
b1 = [b1; eval(projMt) - coef17(1)*Rt^4 - coef17(2)*Rt^3 - coef17(3)*Rt^2 - coef17(4)*Rt^1;];
coef18 = pinv(a1)*b1;
disp('coef18...');

syms plasmatorus1 plasmatorusdiff1;
syms plasmatorusdiff2Rt plasmatorusdiff2Rmt;
syms plasmatorusdiff3Rt plasmatorusdiff3Rmt;
syms size1 size2 i1 i2 curmin testmin minRt minRmt;

plasmatorus1 = coef17(1)*Rt^4 + coef17(2)*Rt^3 + coef17(3)*Rt^2 + coef17(4)*Rt^1;
plasmatorus1 = plasmatorus1 + coef18(1)*Rmt^4 + coef18(2)*Rmt^3 + coef18(3)*Rmt^2 + coef18(4)*Rmt^1;
disp('finished computation of plasmatorus1...');
fprintf(fid, '\n\nplasmatorus1 = Sum of: \n');
for i1 = 1:4
    fprintf(fid, '%20.12f', coef17(i1));
    fprintf(fid, ' Rt^%1i', i1);
    fprintf(fid, '\n');
end
for i1 = 1:4
    fprintf(fid, '%20.12f', coef18(i1));
    fprintf(fid, ' Rmt^%1i', i1);
    fprintf(fid, '\n');
end

plasmatorusdiff2Rt = [coef17(1)*4 coef17(2)*3 coef17(3)*2 coef17(4)*1];
plasmatorusdiff2Rmt = [coef18(1)*4 coef18(2)*3 coef18(3)*2 coef18(4)*1];

plasmatorusdiff3Rt = roots(plasmatorusdiff2Rt);
plasmatorusdiff3Rmt = roots(plasmatorusdiff2Rmt);
fprintf(fid, '\n\nplasmatorusdiff3 = Sum of: \n');
for i1 = 1:3
    fprintf(fid, '%20.12f', plasmatorusdiff3Rt(i1));
    fprintf(fid, ' plasmatorusdiff3Rt^%1i', i1);
    fprintf(fid, '\n');
end
for i1 = 1:3
    fprintf(fid, '%20.12f', plasmatorusdiff3Rmt(i1));
    fprintf(fid, ' plasmatorusdiff3Rmt^%1i', i1);
    fprintf(fid, '\n');
end

size1 = size(plasmatorusdiff3Rt, 1);

```

```

size2 = size(plasmatorusdiff3Rmt,1);

syms plamat1 Rtx Rtmx ptplx1x ptply1x ptplz1x;
plamat1 = coef17(1)*Rtx^4 + coef17(2)*Rtx^3 + coef17(3)*Rtx^2 + coef17(4)*Rtx^1;
lasmat1 = plamat1 + coef18(1)*Rtmx^4 + coef18(2)*Rtmx^3 + coef18(3)*Rtmx^2 + coef18(4)
Rtmx^1;

curmin = 9999999;
for ii1 = 1:size1
    for ii2 = 1:size2
        Rtx = plasmatorusdiff3Rt(ii1);
        Rtmx = plasmatorusdiff3Rmt(ii2);
        testmin = eval(plamat1);
        if or((testmin < curmin), (curmin == 9999999))
            curmin = testmin;
            minRt = Rtx;
            minRtm = Rtmx;
        end
    end
end
disp('finished computation of minimum of plasmatorus eq...');
fprintf(fid, '\n\nMinimum of Plasmatorus Eq Occurs At:');
fprintf(fid, '\nminRt = %20.12f', minRt);
fprintf(fid, '\nminRtm = %20.12f', minRtm);
fprintf(fid, '\n');

syms Rtq Rtmq plasmatorusm;
Rt = minRt;
Rmt = minRtm;
plasmatorusm = coef17(1)*Rtq^4 + coef17(2)*Rtq^3 + coef17(3)*Rtq^2 + coef17(4)*Rtq^1;
plasmatorusm = plasmatorusm + coef18(1)*Rtmq^4 + coef18(2)*Rtmq^3 + coef18(3)*Rtmq^2 +
coef18(4)*Rtmq^1;
disp('finished computation of polynomial eq. of min of plasmatorus eq...');
fprintf(fid, '\n\nplasmatorusm = Sum of: \n');
for i1 = 1:4
    fprintf(fid, '%20.12f', coef17(i1));
    fprintf(fid, ' Rt^%1i', i1);
    fprintf(fid, '\n');
end
for i1 = 1:4
    fprintf(fid, '%20.12f', coef18(i1));
    fprintf(fid, ' Rmt^%1i', i1);
    fprintf(fid, '\n');
end

%
%; general equation of surface of a torus with radiuses Rt and Rtm
%;
syms Surfacel Rtmn Rtmnn;
Surfacel = 4*3.14159*3.14159*Rtmn*Rtmnn;

syms plasmatm Rtqq Rtmqq ptplx1qq ptply1qq ptplz1qq;

plasmatm = coef17(1)*Rtqq^4 + coef17(2)*Rtqq^3 + coef17(3)*Rtqq^2 + coef17(4)*Rtqq^1;
plasmatm = plasmatm + coef18(1)*Rtmqq^4 + coef18(2)*Rtmqq^3 + coef18(3)*Rtmqq^2 + coef18
(4)*Rtmqq^1;

%
%; compute the current equation for ring sizes
%; - polynomial I (10) R1 (10) R2 (10) R3 (10) N1 (10) N2 (10)
%;

```



```

% ; compute a table of current, ring sizes, number of rings, etc.
% ; - for current (1 Amp to 100 Amp) (wait on this)
% ; - ring size 1 (1 to 5 meters)
% ; - ring size 2 (10 to 20 meters)
% ; - ring size 3 (40 to 80 meters)
% ; - # of rings 1 (10 to 20)
% ; - # of rings 2 (10 to 20)
% ; - # of rings 3 (10 to 20)
% ;
% ; some constants:
% ; mass of electron = 9.110 * 10^-31 kg
% ; charge of electron = 1.602192 * 10^-19 C
% ; solenoid constant (u0) = 4*pi*10^-7 T A^-1
% ; solenoid equation: B = u0 * n * I
% ; Gas constant = 8.314 J mol^-1 K^-1
% ; Avogadro's # = 6.022 * 10^23 molecules/mole
% ;
syms melec qelec solu0 gask avogad speedc vor;
melec = 9.110*10^(-31);
qelec = 1.602192*10^(-19);
solu0 = 4*3.14159*10^(-7);
gask = 8.314;
avogad = 6.022*10^(23);
speedc = 2.9979*10^(8);
vor = 100/gask;
syms rsize1 rsize2 rsize3 nrings1 nrings2 minB fperA curl cur2;
syms Efmt Ffmt vfmt nfmt Bpar Fpar Vpar Energy1 Pressure1 Temperature1;
% ; compute and print:
% ; Efmt = speedc*plasmam;
% ; Ffmt = qelec*Efmt;
% ; vfmt = (Ffmt/melec)*60;
% ; nfmt = 2*3.14159/0.05;
% ; Bpar = nfmt*cur2*solu0;
% ; Fpar = qelec*vfmt*Bpar;
% ; vpar = (Fpar/1)*1;
% ; Energy1 = (1/2)*1*vpar^2/vor;
% ; Temperature1 = gask*Energy1;
% ; Pressure1 = vor*gask*Temperature1/(4*3.14159*3.14159*rsize3*rsize3);
fprintf(fid, '\n\nTable of Minimum B Field Due to Various Radius Sizes and Number of
Toruses');
fprintf(fid, '\n');
for rsize1 = 1:2
    for rsize2 = 10:10
        for rsize3 = 40:40
            for nrings1 = 10:11
                for nrings2 = 10:11
                    for nrings3 = 10:10
                        for curl = 1:1
                            for cur2 = 1:1
                                r1 = rsize1;
                                Rtqq = rsize2;
                                Rtmqq = rsize3;
                                nr = nrings1;
                                nT = nrings2;
                                Rtm = Rtmqq;
                                Rtm = rsize1;
                                Rtm = rsize2;
                                minB = eval(plasmam);
                                fperA = minB*eval(Surfacel);
                                Efmt = speedc*plasmam;
                                Ffmt = qelec*Efmt;
                                vfmt = (Ffmt/melec)*60;
                                nfmt = 2*3.14159/0.05;
                                Bpar = nfmt*cur2*solu0;
                                Fpar = qelec*vfmt*Bpar;
                                vpar = (Fpar/1)*1;

```

```

Energy1 = (1/2)*1*vpar^2/vor;
Temperature1 = gask*Energy1;
Pressure1 = vor*gask*Temperature1/(4*3.14159*3.14159*rsize3*rsize3);

```

```

required fperA is a constant from textbook

```

```

disp('inner loop...');
rsizel
rsizel2
rsizel3
nrings1
nrings2
fprintf(fid,'\n');
fprintf(fid,'Ring Size 1 = ');
fprintf(fid,'%20.12f',rsizel);
fprintf(fid,'\n');
fprintf(fid,'Ring Size 2 = ');
fprintf(fid,'%20.12f',rsizel2);
fprintf(fid,'\n');
fprintf(fid,'Ring Size 3 = ');
fprintf(fid,'%20.12f',rsizel3);
fprintf(fid,'\n');
fprintf(fid,'# of Rings 1 = ');
fprintf(fid,'%4i',nrings1);
fprintf(fid,'\n');
fprintf(fid,'# of Rings 2 = ');
fprintf(fid,'%4i',nrings2);
fprintf(fid,'\n');
fprintf(fid,'minB = ');
fprintf(fid,'%20.12f',minB);
fprintf(fid,'\n');
fprintf(fid,'fperA = ');
fprintf(fid,'%20.12f',fperA);
fprintf(fid,'\n');
fprintf(fid,'\n');
fprintf(fid,'curl = ');
fprintf(fid,'%20.12f',curl);
fprintf(fid,'\n');
fprintf(fid,'cur2 = ');
fprintf(fid,'%20.12f',cur2);
fprintf(fid,'\n');
fprintf(fid,'Temperature1 = ');
fprintf(fid,'%20.12f',eval(Temperature1));
fprintf(fid,'\n');
fprintf(fid,'Pressure1 = ');
fprintf(fid,'%20.12f',eval(Pressure1));
fprintf(fid,'\n');

```

```

%;
%;
%;
print both of them for comparison

```

```

end
end
end
end
end
end
end
disp('finished program. ');
st = fclose(fid);

```